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FISCAL YEAR 1989 - 1994 RESEARCH AND TECHNOLOGY PLAN

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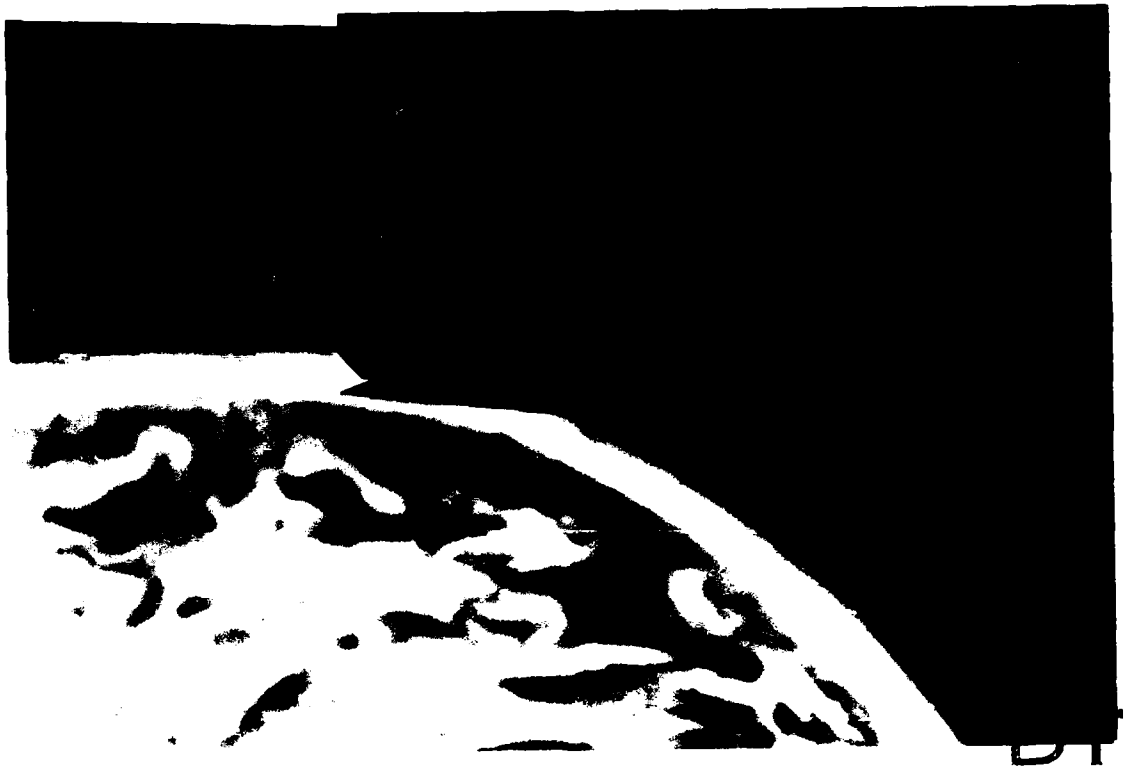

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SPECIAL PROJECTS OFFICE

AIR FORCE HUMAN RESOURCES LABORATORY

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The plans reported here are part of a broader set of plans which are reported in the "Human Systems Technology Roadmap - 1988," published by the Human Systems Division (HSD). The Air Force Human Resources Laboratory (AFHRL), one of several HSD laboratories, is the principal Air Force Systems Command (AFSC) organization charged with planning and executing the USAF exploratory and advanced development programs in manpower and personnel, education and training, simulation and training devices, and logistics and group aspects of human factors. This document contains a description of the laboratory mission and investment strategy; plans for research and development by AFHRL during the period FY89-94; a brief description of program relationships and accomplishments; a list of formal requirements for R&D; and general background information about AFHRL's organization, funding, manpower, and facilities.

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FRONT COVER ILLUSTRATION: PROJECT FORECAST II PICTURE

Project Forecast II was the culmination of an 8-month study at the direction of then Secretary of the Air Force, the Honorable Mr. Verne Orr, and the Air Force Chief of Staff, General Charles Gabriel. The study was concluded on 13 February 1986.

More than 175 people participated in the study representing the Air Force Major Commands, the Air Force Systems Command, and the Air Staff at the Pentagon.

More than 2000 ideas were generated during the study from government, industry, and academia. The ideas were screened and the Air Force is pursuing some seventy technology and systems ideas that will be the source of future Air Force technologies over the next two decades.

The artist's drawing on the front cover illustrates the National Aerospace Plane, which will use revolutionary rather than evolutionary advances in propulsion and material to achieve performance in an entirely new regime.

The primary technological advances have occurred in the areas of advanced propulsions and lightweight, high-strength, high-temperature materials.

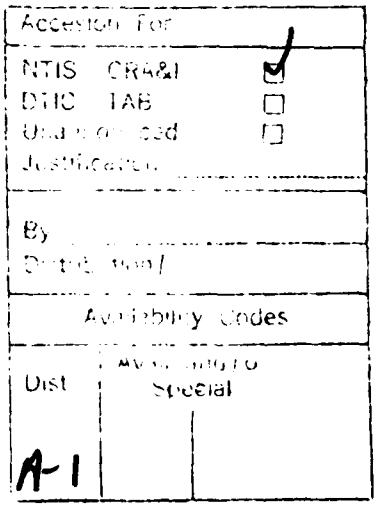
The revolutionary vehicle could be of advantage to both the civilian/commercial and the military sectors --very similar to the space shuttle.

AFHRL is actively involved in three Forecast II efforts and acts in a consulting capacity for many others.

PREFACE

The Air Force Human Resources Laboratory (AFHRL) is part of the Human Systems Division (HSD), one of many product divisions within the Air Force Systems Command (AFSC). The official plans for AFHRL (with budget attached) are contained in an HSD document entitled "Human Systems Technology Roadmap for FY88." That document is available only to qualified Government personnel on request. However, general information about the AFHRL organization can be found in the HSD Annual Report, which is readily available.

The present document contains detailed information about AFHRL plans at the Laboratory's division level. These Division plans are only a subset of the others contained in the HSD Roadmap document, but they are described here in greater detail. Detailed funding information has not been included in order that the document may be made available to the widest possible audience. The document is intended for review by contractors and requirements managers who need detailed information about plans of specific AFHRL divisions.



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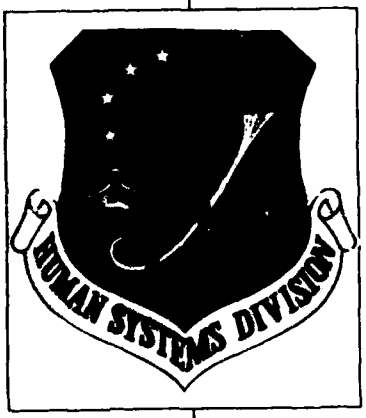

I. AFHRL CHAIN OF COMMAND

THE DEPARTMENT OF THE AIR FORCE

The mission of the Department of the Air Force is "to provide an Air Force that is capable, in conjunction with the other Armed Forces, of preserving the peace and security of the United States, providing for its defense, supporting the national policies, implementing the national objectives, and overcoming any nation responsible for aggressive acts that imperil the peace and security of the United States." Teamed with the Army, Navy, and Marine Corps, the Air Force is prepared to fight and win any war if deterrence fails.

AIR FORCE SYSTEMS COMMAND

Major Commands are interrelated and complementary, providing offensive, defensive, and support elements. Each support function, such as logistics, training, and research and development, is under the jurisdiction of a separate command. Air Force Systems Command (AFSC) is one such command. Under policies established by HQ USAF, AFSC's mission is to advance aerospace technology, to incorporate those advances in the development and improvement of aerospace systems, and to acquire qualitatively superior, cost-effective, and logistically supported aerospace systems and equipment. It is through AFSC that USAF's operational and support commands receive the weapons, equipment, and initial spare parts needed to defend the nation.

AIR FORCE HUMAN SYSTEMS DIVISION

The Human Systems Division (HSD) is a subordinate element of AFSC. HSD plans, manages, and conducts research, engineering development, and acquisition programs and provides specialized operational support. Its efforts focus upon the readiness, maintenance, protection and enhancement of human capabilities and human system performance of individuals, teams, crews, and force levels. It serves as a center for human systems advocacy, enabling the Air Force to meet current and future operational requirements in the four functional areas of crew-system integration, crew protection, force readiness, and environmental protection.

AIR FORCE HUMAN RESOURCES LABORATORY

The Air Force Human Resources Laboratory (AFHRL), an organization of HSD, has the responsibility of managing and conducting research, exploratory and advanced development programs for manpower and personnel, flying and technical training, simulation, and logistics systems. The overall goal of the combined programs is to assist the Air Force in achieving the best methods for acquiring enlisted and officer members, and training and maintaining this force at peak readiness.

II. HOW TO USE THIS DOCUMENT

Unsolicited proposals to conduct research leading to the attainment of any of the objectives presented in this document may be submitted directly to an Air Force laboratory. However, before submitting a formal proposal, we encourage you to discuss your approach with the laboratory point of contact. After such discussion or correspondence, you will be better prepared to write your proposal.

As you read through the pages that follow, you may see a field of endeavor where your organization can contribute to the achievement of a specific technical goal. If such is the case, you are invited to discuss the objective further with the scientist or engineer identified with the objective. Further, you may have completely new ideas not considered in this document which, if brought to the attention of the proper organization, can make a significant contribution to our military technology. We will always maintain an open mind in evaluating any new concepts which, when successfully pursued, would improve our future operational capability.

On behalf of the Air Force, you are invited to study the objectives listed in this document and to discuss them with the responsible laboratory personnel. Your ideas and proposals are most welcome.

As stated in AFSC Pamphlet 70-5, AFSC Guide for Unsolicited Proposals (copies of this guide on unsolicited proposals are available by writing to Air Force Systems Command/PMPR, Andrews Air Force Base (AFB), Washington, DC 20334), elaborate brochures or presentations are definitely not desired. The "ABCs" of successful proposals are accuracy, brevity, and clarity. It is extemely important that your letter be prepared to encourage its reading, to facilitiate its understanding, and to impart an appreciation of the ideas you desire to convey. Specifically, your letter should include the following:

1. Name and address of your organization.

2. Type of organization (profit, nonprofit).

3. Concise title and an abstract of the proposed research, and a statement indicating the submission is an unsolicited proposal.

4. Outline and discussion of the purpose of the research, the method of attack on the problem, and the nature of the expected proposal.

5. Name and research experience of the principal investigator.

6. Suggestion as to the proposed starting and completion dates.

7. Outline of the proposed budget, including information on equipment, facility, and personnel requirements.

8. Names of any other Federal agencies receiving the proposal. (This is extremely important.)

9. Brief description of your facilities, particularly those that would be used in your proposed research effort.

10. Brief outline of your previous work and experience in the field.

11. Descriptive brochure and financial statement, if these are available.

III. LABORATORY MISSION AND INVESTMENT STRATEGY

The Air Force Human Resources Laboratory (AFHRL) is the principal Air Force Systems Command (AFSC) organization charged with planning and executing the USAF exploratory and advanced development programs for research related to manpower and force management, logistics systems technology, and training technology. Manpower and force management research and development (R&D) addresses selection, classification, assignment, evaluation, and retention of Air Force members and overall force structure and utilization. Logistics systems R&D is concerned with logistics factors at each step in the development and acquisition of systems and the productivity of maintenance teams. Training technology R&D addresses the development of improved methods for training, including content, instructional strategies, delivery, evaluation, and management. Aircrew training R&D includes manned aircraft simulation, performance measurement, training technology for air combat tactics, and advanced systems to improve the quality and combat effectiveness of aircrews. Command and control (C^2) includes training to improve team performance, C^2 team performance assessment, and information systems to facilitate team performance. Technical training R&D includes the use of computer-assisted methods to improve training systems, instructional and learning strategies, techniques for managing training, and techniques for evaluating job performance.

The goal of the AFHRL Investment Strategy is to help ensure combat success by optimizing human performance. This human-oriented approach is based on an increasing awareness that complex systems require detailed identification and training of personnel for operations, maintenance, and support.

The Investment Strategy at AFHRL has five primary considerations:

1. Support of AFSC's Forecast II program, which is concerned with the development of new technologies to meet specific weapon system needs.

2. Integration of Manpower, Personnel, and Training (MPT) technologies early in the weapon system acquisition cycle.

3. Adherence to a balance between technology base development and technology application in support of customer requirements.

4. Capitalization on emerging technologies which directly impact the formulation and accomplishment of the R&D program. Examples of these technologies are artificial intelligence, miniaturized computer hardware, sophisticated software, visual display technologies, and weapon system design technologies.

5. Review of the above considerations in the larger context of support to the total Human Systems Division (HSD), AFSC, and Air Force mission.

Investment strategy is also impacted by formal long-range planning guidance such as Air Force 2000, Air Force-endorsed Defense Science Board studies and recommendations, Air Force Logistics Long Range Planning Guide, AFSC 1990, HSD 1990, the VANGUARD planning process, Forecast II, and other requirements levied by the Air Force. Other program guidance is provided periodically by both HQ AFSC and HQ HSD.

Guided by inputs from Divisions, the AFHRL Commander has made specific decisions about changes in program emphasis during the FY89 - 94 time period. The R&D emphasis in manpower and force management will expand in the areas of Manpower, Personnel, and Training (MPT) integration technology and aircrew selection. Emphasis on the Comprehensive Occupational Data Analysis Programs (CODAP) and the Methodology for Generating Efficiency and Effectiveness Measures (MGEEM) will decrease, since the technical work in these areas is largely complete and the technologies have already been transitioned to user organizations. In the area of logistics technology, increased emphasis will be given to two 6.3 projects during FY89 - 90: Computer-Assisted Logistics Support (CALS) and Integrated Maintenance Information System (IMIS). The work on IMIS will gradually decrease in subsequent years as the technology is transitioned to user organizations. In the area of training technology, increased emphasis will be given to eye-tracker development for aircrew simulators, electronic combat training, on-the-job training management and delivery, and intelligent computer-assisted instruction. Decreased emphasis will be given to Part-Task Training (PTT) hardware development and minor improvements to traditional forms of computer-based training and instructional support systems.

Advance planning is the primary method of assuring that R&D resources are invested in technologies that meet the needs of the Air Force in a timely manner. The AFHRL Investment Strategy is implemented through a planning and programming process which is organized around the DOD Planning, Programming, and Budgeting System (PPBS). The following activities constitute the AFHRL 30-month planning cycle:

1. Thirty months in advance of the fiscal year in which an effort will start, division scientists prepare individual work unit proposals in accordance with the considerations outlined above. Each proposal identifies and justifies the R&D being proposed, provides detail on the technical approach, and specifies the technology to be enhanced or the customer requirement to be satisfied.

2. Program proposals are reviewed by the Laboratory Commander and are tentatively approved if they comply with the investment strategy criteria given above. Other reviews may be conducted by the AFHRL Technical Advisory Board and/or by a Research Advisory Panel of nationally recognized experts. While these reviews are ongoing, the need for front-end analysis is evaluated by the staff of the Special Projects Office. When considered to be necessary, formal front-end analyses (FEAs) of major programs are completed and incorporated into the review and approval process. Policies guiding FEAs are contained in AFHRLR 173-1, Front End Analysis (FEA) Studies, February 1988.

3. After preliminary reviews are completed, AFHRL scientists develop work unit packages in compliance with AFHRLR 80-4, Laboratory Work Unit Planning, Prioritization, Approval, and Completion Procedures, 24 January 1986, which detail the technical plans, resource requirements, and justification for each work unit.

4. The final review authorizing a new start is made by the Commander prior to the proposed program start. Approval is based on the merit of the proposal, priority of the program, and the availability of resources.

IV. BASIC RESEARCH PROGRAMS (6.1)

AFHRL conducts basic research under two Air Force Office of Scientific Research (AFOSR) tasks: (1) Manpower Management, and (2) Perceptual and Cognitive Dimensions of Pilot Behavior. This research is accomplished in-house as well as by various contractors.

Learning Abilities Measurement Program

The Learning Abilities Measurement Program (LAMP) investigates the nature and organization of human learning abilities, with the ultimate goal of contributing to a new model-based selection and classification system for the United States Air Force. The program attempts to define systems for measuring fundamental human characteristics such as information processing speed, working memory capacity, and parameters associated with factual and procedural knowledge bases. LAMP research conducted thus far has resulted in a tentative model of the mental skills responsible for the ability to learn. The model states that an individual's skill and knowledge levels vary along four major dimensions: working memory capacity, information processing speed, factual knowledge, and procedural or strategic knowledge. The model also assumes that these four skill dimensions interact. The importance of having a model of learning ability is that the model can suggest means for constructing new kinds of ability tests, and can also serve as the basis for new task analysis systems. The model will eventually help specify what kinds of cognitive skills ought to be measured in order to develop equations for predicting the likelihood that a person will succeed in training and on the job.

A laboratory facility for studying skill acquisition has been established at Lackland AFB. This facility consists of 30 Artificial Intelligence (AI) workstations that are used to deliver intelligent tutoring system software that provides training in computer programming, basic electronics, and flight engineer functions. During the next few years, LAMP will investigate the underlying cognitive components of skills acquisition in these domains. Currently, LAMP researchers are addressing ways of sampling what a person knows in order to develop profiles of that individual's knowledge base. Progress is expected to lead to a taxonomy of knowledge types and learning by FY89. A technology for cognitive task analysis is expected in the FY90 timeframe.

The ultimate payoff in the LAMP work is the development of new procedures for measuring abilities. All of the preliminary work is designed to facilitate this end result.

The Learning Abilities Measurement Program investigates the nature and organization of human learning abilities.

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Perceptual and Cognitive Dimensions of Pilot Behavior

The pilot behavior research program deals with issues related to the cognitive and perceptual aspects of human visual information processing. There are currently two efforts underway: (1) visual attention, and (2) form processing across the retina.

The basic research program at the Operations Training Division of AFHRL is focused on the fundamental cognitive and perceptual processes associated with human vision.

The visual attention research is concerned with what aspects of the visual world will be selected for attention. One line of research deals with covert visual attention shifts (i.e., attention shifts without eye movement). The objectives of this effort are: to measure the time course of attention shifts, to determine what kinds of visual information are enhanced by covert attention, to assess the effects of practice on shifting speed and information processing, and to develop a model of covert attention effects. Another line of visual attention research deals with how intelligence and strategy determine each individual eye movement when the task is goal-driven. The objective is to develop a computational model of the decision processes required for each eye movement. This R&D employs artificial intelligence techniques to derive rules for predicting patterns of eye movements during simplified flight instrument crosscheck tasks.

The second major effort in the pilot behavior basic research program addresses the manner in which visual information is processed across the retina (including the visual periphery). The emphasis is on determining what aspects of a visual stimulus convey form information and how the underlying mechanisms operate, change and interact with each other at various retinal eccentricities. This research will be accomplished by applying psychophysical techniques to study the perception of specified images which are created and manipulated by elementary function techniques (e.g., Fourier descriptors and two-dimensional Gabor functions). The long-range goal is to provide enough understanding of visual systems functions in the periphery to allow for the design of displays that are optimally matched to human information processing abilities.

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V. TECHNOLOGY PROGRAMS (6.2 AND 6.3)

Manpower and Force Management

General Objective

This R&D develops better ways of selecting people and assigning them to Air Force specialties; determines job and training requirements for specialties; and estimates the impacts of policy changes on the manpower and personnel process. The results will provide the basis for a variety of manpower policy decisions. Better methods are being developed for the procurement and selection of quality personnel; for the assignment of people to jobs compatible with their aptitudes, interests, and experience; for the establishment of effective reenlistment and career development programs; and for the design of improved decision aids for Manpower, Personnel, and Training (MPT) management.

Specific Goals and Technical Approaches

1. Personnel Assessment Systems. Although personnel assessment systems are well established in the Air Force, considerable R&D is required in order to maintain the existing measurement systems and develop new ones that can capitalize on recent developments in computer technology. It is important that a sound long-range plan guide these activities, and that they proceed in an orderly manner if they are to yield quality operational versions of specific test instruments backed up by solid supporting research. State-of-the-art technology will be applied to problems of test battery development, evaluation, standardization, and maintenance whenever possible. Systematic development of both new test content areas and numerous other tests not in current use will also be initiated, and the potential of these tests for improvements of operational test batteries--especially for prediction of job performance--will be evaluated.

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Figure 1 outlines the plans for the personnel assessment thrust in the form of an activity flow chart (as indicated in the preface, these are a small subset of activities in the HSD roadmap document). During FY89 - 94, we will continue to develop prototypes for both the enlisted and officer test batteries. Future R&D will explore possible computer-based/computer-adaptive approaches to both officer and enlisted selection and classification. Development of selection and classification test procedures hinges on the traditionally difficult task of developing good job performance measures. When these measures are available, techniques for test development and improvement of job performance will be possible. Development, evaluation, refinement, and application of performance measures will continue, as will test-validation/evaluation and cost/benefit analyses. In addition, as good job performance measures become available, test development research will begin to focus on the identification of new measures (both paper-and-pencil and computer-based) which are most relevant to actual job performance.

a. LAMP-Enhanced Selection Test Methods. In FY89, the basic research conducted as part of the Learning Abilities Measurement Program (LAMP) will result in the development of some LAMP-enhanced selection tests. Several years will be required to design and evaluate

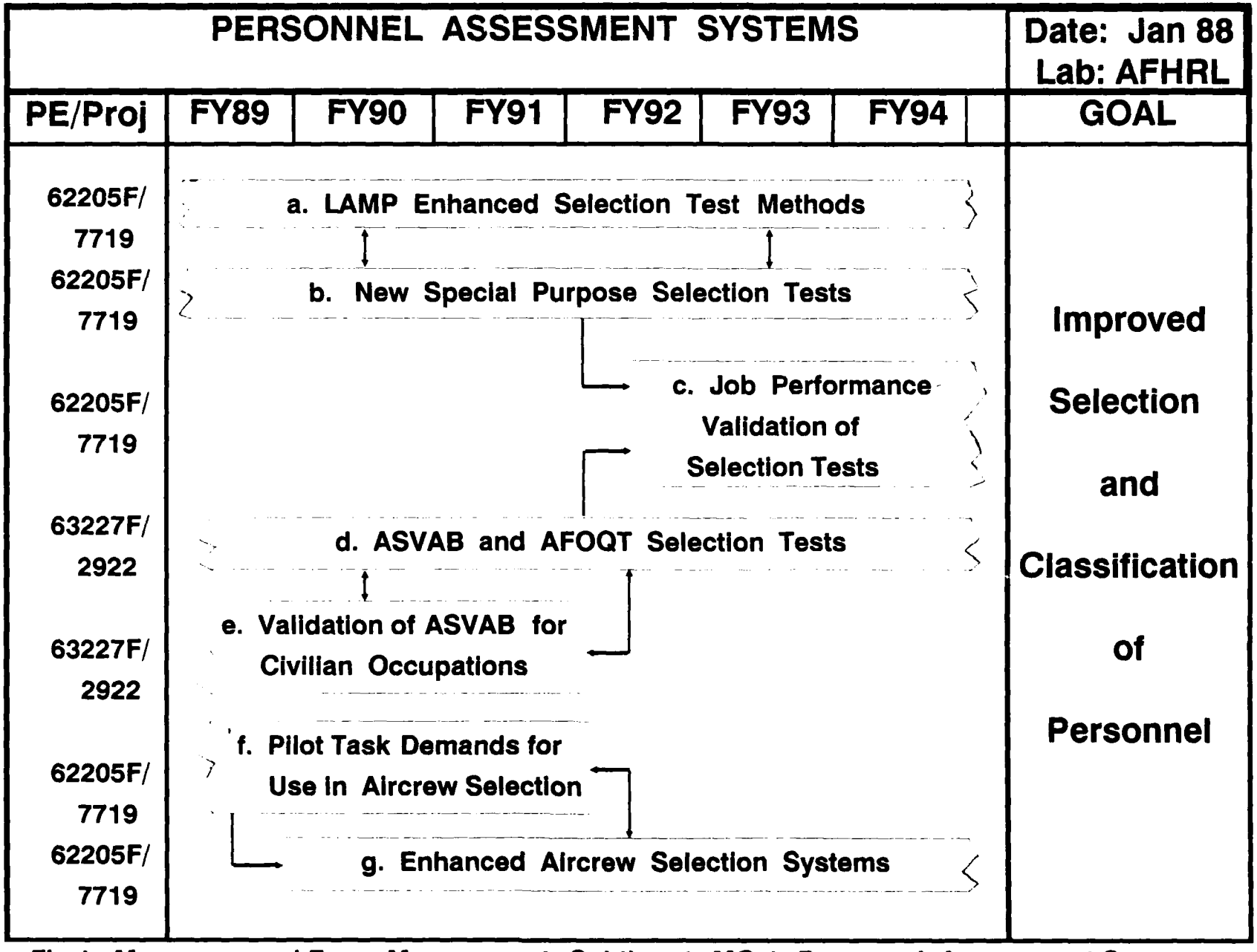


Fig 1. Manpower and Force Management Subthrust MO-1: Personnel Assessment Systems.

these new learning skill tests because of the need to validate the tests over time. Examples of learning skill tests that might be developed are working memory capacity and information processing speed.

b. New Special Purpose Selection Tests. A wide variety of selection tests will be validated and enhanced during FY89 - 92. Newer techniques will be applied to the analysis of test items and scales, final test evaluation, and supporting R&D. R&D to maintain and improve conventional paper-and-pencil tests will continue until such time as they can be replaced by computer-based/computer-adaptive test systems. New R&D will develop computer-based/computer-adaptive systems and tests that improve prediction of job performance.

c. Job Performance Validation of Selection Tests. During FY93 - 94, tests developed during FY89 - 92 will be validated. Validation is dependent upon good job performance measures, which will be developed by the Manpower and Personnel Division as well as by other AFHRL Divisions.

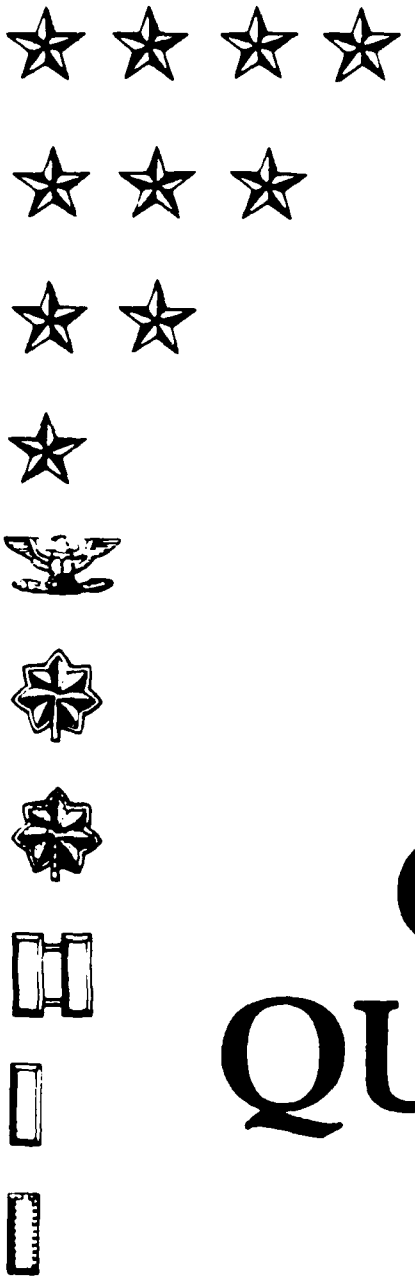
d. ASVAB and AFOQT Selection Tests. The Air Force is the lead Service for conducting R&D in support of the Armed Services Vocational Aptitude Battery (ASVAB) testing programs, and works closely with the Army, Navy, Marine Corps, and Coast Guard to establish enlistment qualifications and to make initial enlisted job classification and assignment decisions. In addition, special forms of the ASVAB are used in the Department of Defense (DOD) high school testing program. During FY89 - 92, AFHRL will be responsible for developing test items for ASVAB Forms 18, 19, 20, 21, and 22. Supporting studies include: impacts on the tests of various techniques for item analysis, selection and test score standardization; studies of a test's utility or validity for making sound selection and job assignment decisions; studies of test bias (Is the test "fair" to various population subgroups?); studies of the basic factors underlying the test scores; and development of scoring keys called "Deliberate Failure Keys" to detect deliberate test failure (these are required for use in the event of a national mobilization). Similar studies will be conducted for the Air Force Officer Qualifying Test (AFOQT) during the same time period. In the case of the AFOQT, however, the AFHRL work is focused upon Air Force needs rather than the needs of all military Services.

ASVAB--Selection and classification test used by all the Services.

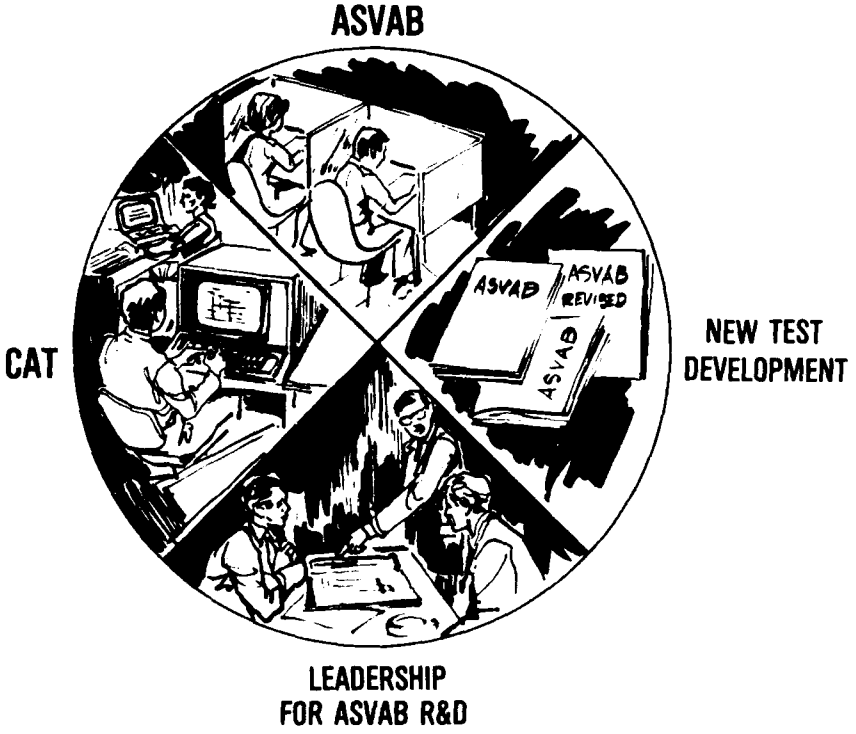
COMPOSITES	SUBTESTS: GENERAL SCIENCE	WORD KNOWLEDGE	PARAGRAPH COMPREHENSION	ARITHMETIC REASONING	MATH KNOWLEDGE	AUTO & SHOP INFORMATION	MECHANICAL COMPREHENSION	ELECTRONICS INFORMATION	CODING SPEED
ACADEMIC ABILITY		●	●	●					
VERBAL	●	●	●						
MATH				●	●				
MECHANICAL AND CRAFTS				●		●	●	●	
BUSINESS AND CLERICAL		●	●		●				●
ELECTRONICS AND ELECTRICAL	●			●	●			●	
HEALTH SOCIAL AND TECHNOLOGY		●	●	●			●		

Matrix of Composites and ASVAB Subtests

UNITED STATES AIR FORCE



OFFICER QUALIFYING TEST



e. Validation of ASVAB for Civilian Occupations. One of the more interesting plans for ASVAB is the validation of ASVAB Form 14 for civilian occupations. This will take place during FY89 - 91, using a variety of criterion measures and a variety of occupational specialties. The information is needed for joint-Service recruitment efforts.

f. Pilot Task Demands for Use in Aircrew Selection. A study of pilot task demands for use in aircrew selection will be conducted during FY89 - 91. This will serve as a foundation for the aircrew selection tests that will be developed later. This task will grow in importance with the implementation of Specialized Undergraduate Pilot Training (SUPT).

g. Enhanced Aircrew Selection System. An enhanced aircrew selection and classification test battery will be developed during FY89 - 94.

In addition to the development of a portable computer-driven pilot testing program, aircrew R&D includes the development of measures for the classification of pilot trainees into multi-track training programs (fighter, multi-engine) and the prediction of operational flying criteria. R&D in the FY89-94 time period will focus on quantifying the aircrew task demands expected in the high-performance cockpits of the future and in translating these demands into selection and/or training programs (FY90). The acquisition of piloting skills will also be tracked to determine how initial abilities of the student contribute to progress in different phases of training. This R&D will increase our understanding of how basic attributes measured during the selection process can be weighted to optimize performance in training and in the cockpit (FY91).

2. MPT Requirements. Congressional mandates and operational needs emphasize the technical challenge and urgency of integrating the various individual Manpower, Personnel, and Training (MPT) technologies. The MPT requirements subthrust (initiated in FY86) will develop the technologies, models, and data bases needed to support the utilization of MPT requirements information when weapon system design tradeoff decisions are made. The subthrust will also develop personnel and training pipeline and retraining systems for fielding new weapon systems, and for integrating MPT decision processes into existing systems. In addition, a prototype training system for teaching problem solving skills to airmen in high technology specialties will be developed.

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Plans for the MPT requirements subthrust are outlined in the activity flow chart shown in Figure 2. Job measurement technologies are an important part of the subthrust, because they can be used to provide an objective and unified assessment of Air Force job requirements. The new technologies will be designed to provide operational, quantitative, and accurate measurement techniques for assessing, analyzing, and matching job requirements and personnel capabilities. Specifications are needed in the areas of aptitude, physical strength, educational level requirements, basic job skills, and job analysis methodologies. Applications of these technologies are critically important in analyzing the interrelationships and tradeoffs associated with MPT policy options for both existing and emerging weapon systems.

In current practice, decisions on occupational structuring, entry-level requirements for specialties, educational standards, and other requirements are made somewhat subjectively, based on the personal knowledge and experience of decision makers whose responsibilities are often spread over wide responsibility areas. Their decisions are usually made under severe time pressures and without adequate information sources or standards to draw upon. Major decisions about policy changes are coordinated through numerous offices of primary responsibility (OPRs)--which takes time. One result of this process is that initially good recommendations may become obsolete by the time they are implemented. Another problem is that at no place in the decision chain is there an integrated picture of the overall long-term effects of alternative policies throughout MPT.

The need for an overall, long-range viewpoint is important. For example, if entry-level requirements are tightened, an immediate result is the reduction in the number of available candidates, with impacts on recruiting and fill rates. If entry-level aptitude cutoffs are substantially lowered, the fill is easily made, but the ripple effects may impact on training attrition and on training workloads in terms of needs for individualized job skills assessment, and requirements for simplified technical orders, job performance aids, and new training technologies.

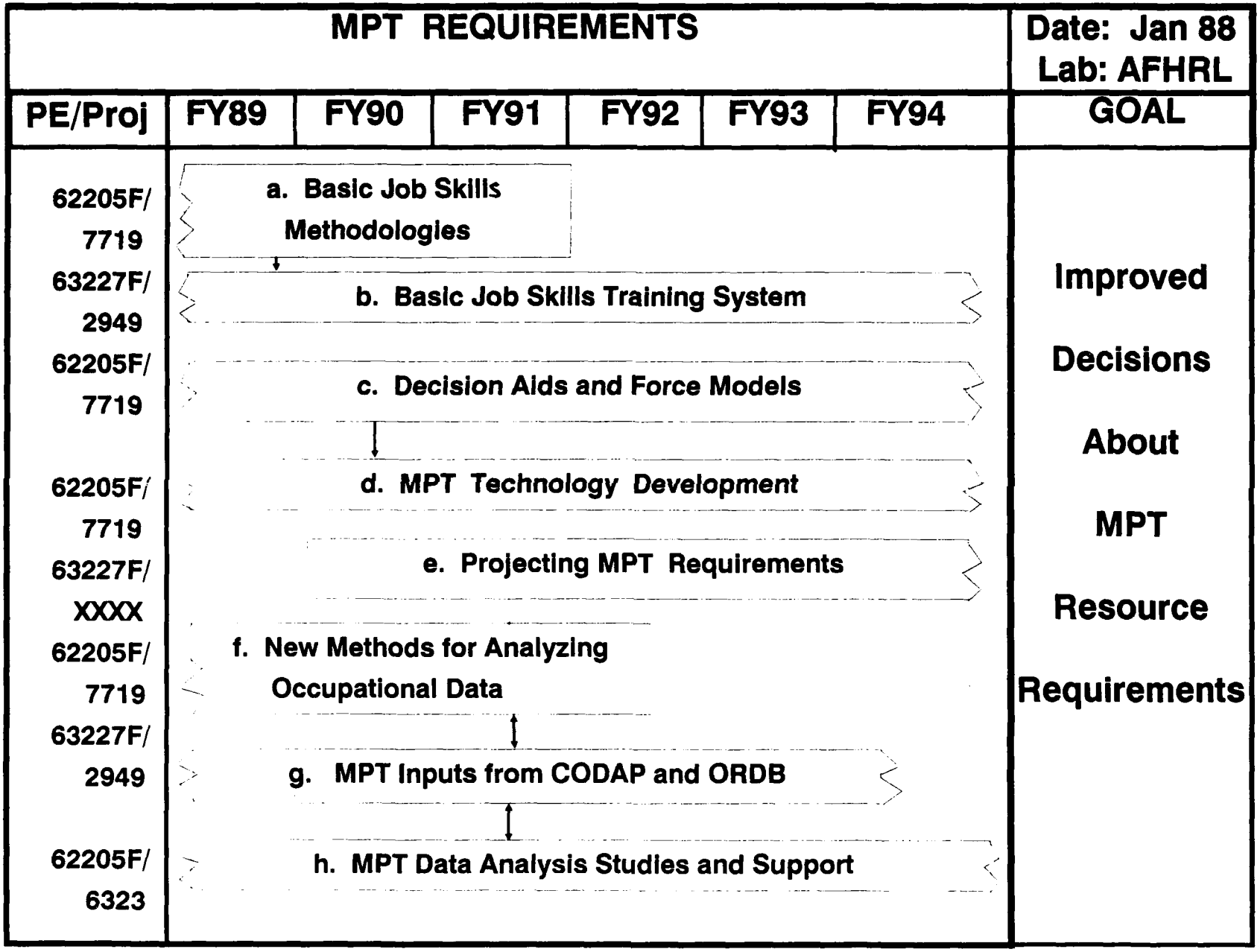
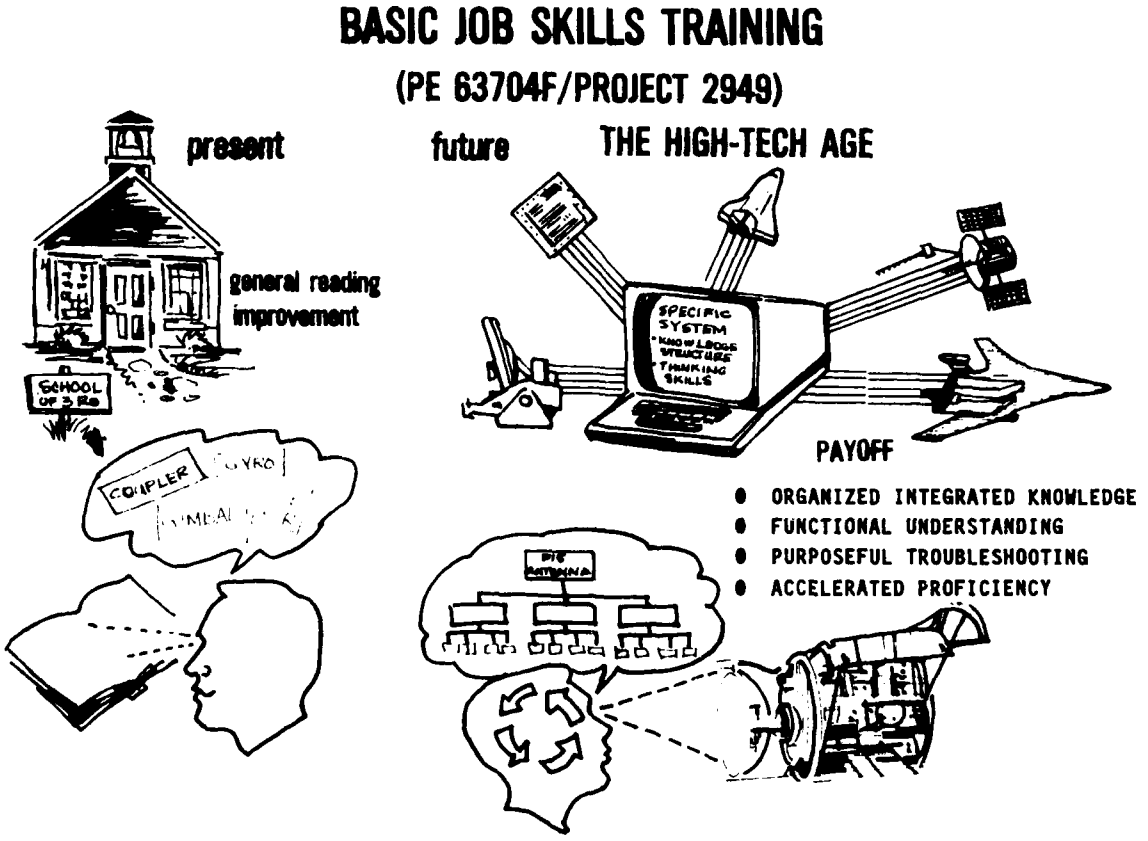


Fig 2. Manpower and Force Management Subthrust MO-2: MPT Requirements.

Since training and personnel management responsibilities are presently divided among numerous OPRs, competing goals are often inevitable, and short-term fixes within limited areas can suboptimize total system effectiveness. What is new in the proposed approach is the concerted direction, increased level of effort, and expansion of a family of previously separate but related technologies toward the single oal of providing a unified approach to defining job specifications and training requirements. These are seen as the essential foundation for all major personnel management functions. Success in the integration of MPT decision processes is expected on the basis of past successes in component R&D areas.

Major areas within the MPT requirements subthrust are as follows:

a. Basic Job Skills (BJS) Methodologies. This R&D will assess and measure the basic job skills that first-term airmen need to gain proficiency in high-technology (high-tech) Air Force specialties. Basic Job Skills are defined as the core knowledge and thinking processes that underlie apprenticeship competence across the most technically demanding jobs in the Air Force--they represent the components of scientific literacy needed for performance in today's high-tech Air Force. The exploratory development work in the BJS effort is concerned with three things: using recently developed cognitive task analysis techniques to determine the problem solving skills and knowledge needed by airmen; developing the diagnostic achievement tests to determine what an airman knows and then prescribing a training regime; and designing specifications for training in high-tech specialties (FY89 - 91).



b. Basic Job Skills (BJS) Training System. The information gained from the exploratory development effort described above will be used to develop BJS prototype training systems, consisting of a series of developmental trainers. These will be specifically designed to enhance those basic job skills needed to achieve competence in highly demanding, technology laden Air Force work environments (FY89 - 94).

c. Decision Aids and Force Models. Decision systems and models are important parts of the MPT requirements subthrust. They provide managers at all levels with tools to make the vitally important decisions for competing MPT resources. Examples of models to be developed are: a retraining person-job match (PJM) model (FY89); a methodology for estimating the value of Air Force experience (FY89); a cost benefit/utility analysis model of MPT research (FY89); a joint accession/retention model (FY90); a costing model (FY90); a civilian labor market model (FY90); a military permanent change of station (PCS) costing model (FY90); a civilian labor market model (FY90); and a military labor market model (FY91).

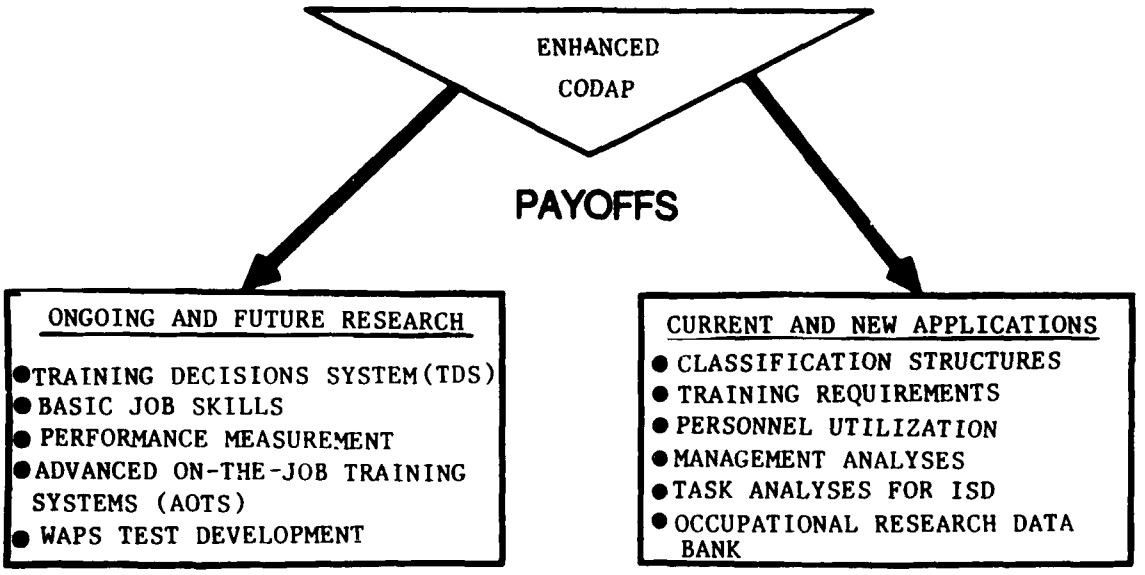
d. MPT Technology Development. The central effort in the MPT requirements subthrust is the work on new MPT technologies. Examples of new technologies that will be addressed are: a technology for measuring the skill and knowledge requirements of clusters of homogeneous specialties (FY89); transferability of skills matrices across specialties (FY89); ways of estimating the MPT requirements of emerging weapon systems (FY89); procedures for clustering tasks into efficient jobs, and jobs into supportable specialties for emerging weapon systems (FY89); the evaluation of more flexible and effective Air Force Specialty Code (AFSC) structures (FY90); an MPT demonstrator to show the implications of MPT mixes and to permit users to articulate their technology needs (FY90); and software for formatting Logistics Support Analysis Records (LSARs) and linking them to Instructional Systems Development (ISD) training requirements (FY90).

e. Projecting MPT Requirements. The exploratory work described above will lead to an advanced development program concerned with projecting MPT requirements. Key products will be: development of an aptitude requirement estimator (FY91); advanced software for the interface between Logistics Systems Analysis (LSA) and Instructional Systems Development (ISD) (FY92); procedures for simulating Air Force Specialty (AFS) structures for specific situations (FY92); a personnel availability forecaster (FY93); a model for estimating transferability of skills (FY94); and a Technical Training Impact Model (TTIM) that will permit personnel and training requirement managers to interact with each other and look at tradeoffs between aptitude standards and training resource requirements (FY94).

f. New Methods for Analyzing Occupational Data. Important inputs for the work on projecting MPT requirements will be provided by new methods for analyzing occupational data (FY89 - 91) The needs of Air Training Command (ATC), the Air Force Military Personnel Center (AFMPC), and the Air Staff for occupational data base management will be investigated, particularly as they relate to MPT integration. Those needs that cannot be met by the existing Occupational Research Data Bank (ORDB) will be considered for inclusion during future developments. The use of artificial intelligence (expert systems) in analyzing occupational data will be explored.

g. MPT Inputs from CODAP and ORDB. Enhanced capabilities will be developed for profile analysis, multidimensional scaling, regression analysis, and factor analysis. Work on expert systems of job analysis will be conducted, including search and heuristic techniques, pattern recognition, semantic information processing, and graphical methods of data analysis and presentation. With the aid of these new methods, it will be possible to develop advanced MPT inputs using CODAP analysis systems and the ORDB.

OCCUPATIONAL MEASUREMENT TECHNOLOGY



h. MPT Data Analysis Studies and Support. Because of its many data files and data analysis capabilities, AFHRL is often asked to conduct quick response studies for a variety of headquarters organizations in the Air Force. Quick response data analysis studies are frequently conducted by the Manpower and Personnel Division (AFHRL/MO) or the Information Sciences Division (AFHRL/TS) for AFMPC, HQ ATC, and a variety of Air Staff offices. Most of these studies are conducted in-house or with the aid of established task ordering contractors, since the small size, quick response nature and the requirement for intimate knowledge of data base capabilities tend to preclude the use of new competitive procurements.

Logistics Technology

General Objective

Logistics technology R&D will develop draft specifications and standards to allow the design and procurement of more reliable and maintainable weapon systems, electronic job aids for maintenance, and will demonstrate more effective ways of performing combat maintenance. The results will influence Major Command (MAJCOM), USAF, and DOD logistics planning for combat operations.

This technical area focuses on using information systems technology to enhance logistics processes. Information systems must be designed such that Air Force personnel can access quickly the information needed for immediate decisions or tasks. Better information systems require better methods for interfacing computers, for exchanging information among data bases, for structuring data, for aiding decisions, for modeling and analysis, and for displaying information. Research underway covers a broad spectrum, ranging from human information processing to the use of computer-aided design, life-cycle engineering, and data base design. Planned technology developments not only will influence the design and acquisition of new weapon systems but also will provide technicians with computer-based aids for maintaining the weapon systems under austere deployment conditions.

Specific Goals and Technical Approaches

1. Acquisition Logistics Systems. Two high-level initiatives are spurring work in acquisition logistics. The Computer-Aided Acquisition and Logistics Support (CALS) program is a multi-Service program directed by the Office of the Secretary of Defense. The Unified Life-Cycle Engineering (ULCE) project is an important component of Forecast II--the Air Force Systems Command's effort to advance key military technologies and systems. The CALS program and the ULCE project technology have complementary goals. CALS seeks to achieve improved supportability and sustainability through integration and automation of a large portion of the acquisition support process sustaining engineering and field organizations via networked computer-based information design and manufacturing processes. The overall objective of ULCE is to develop, demonstrate, and transfer to application, by 1995, the technologies needed to provide integration of design-for-producibility and design-for-supportability goals with design-for-performance, design-for-cost, and design-for-schedule goals. AFHRL work in acquisition logistics supports both CALS and ULCE.

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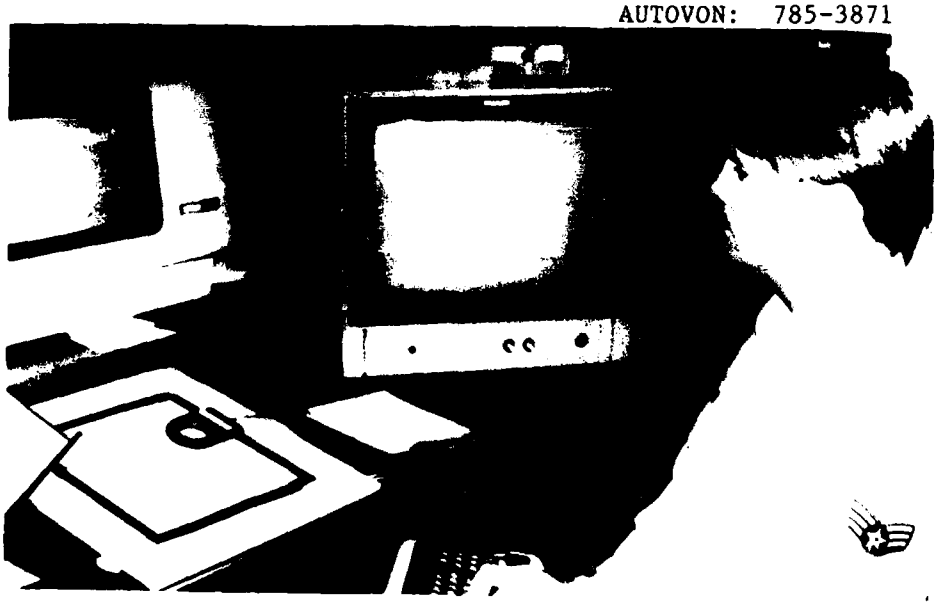

Figure 3 is an activity flow chart for the Acquisition Logistics Systems subthrust.

a. Information Modeling. This R&D addresses the requirements, definition, and development of integrated information system methodologies to support the design and operation of the large complex, distributed, heterogeneous information systems associated with Air Force weapon systems. Methodology development and tool development will continue through FY94.

b. IDS Concept Extension. The Integrated Design Support (IDS) System will demonstrate advanced software and communication architectures for the coordination, preservation and retrieval of weapon system engineering design technical data for DOD use. DOD does not currently obtain or retain adequate technical information for the complete logistics support (remanufacturing, third-party parts suppliers, replacements for obsolete parts, etc.) of most weapon systems. As a result, DOD is dependent on primary contractor support for the life of the weapon system. The IDS program will develop a digital software architecture that will advance existing capabilities for the acquisition, storage, retrieval, coordination, and communication of weapon systems technical design data, design specifications, manufacturing methods, and parts fabrication information.

An IDS Technical Advisory Group (TAG) has been established. It consists of a group of representatives from aerospace, computer, and aircraft engine industries that reviews and critiques the IDS program. The TAG helps assure that IDS meets the requirements of aerospace design, manufacturing, and logistics and helps facilitate technology transfer. Meetings are held three times a year in April, August, and December.

Phase I, completed in FY87, concentrated on the requirements definition, initial function, and information modeling and development of a concept demonstration software system. If budget resources allow, Phase II will extend the function and information models, and will modify and improve the software testbed to focus on a selected Air Logistics Center (ALC). The FY87 contract will run for 4 years. The software system will be demonstrated annually in December. Model refinements will be accomplished by FY89, and a prototype demonstration system will be implemented by FY90. A prototype IDS system demonstration in an ALC environment will be completed in FY91.

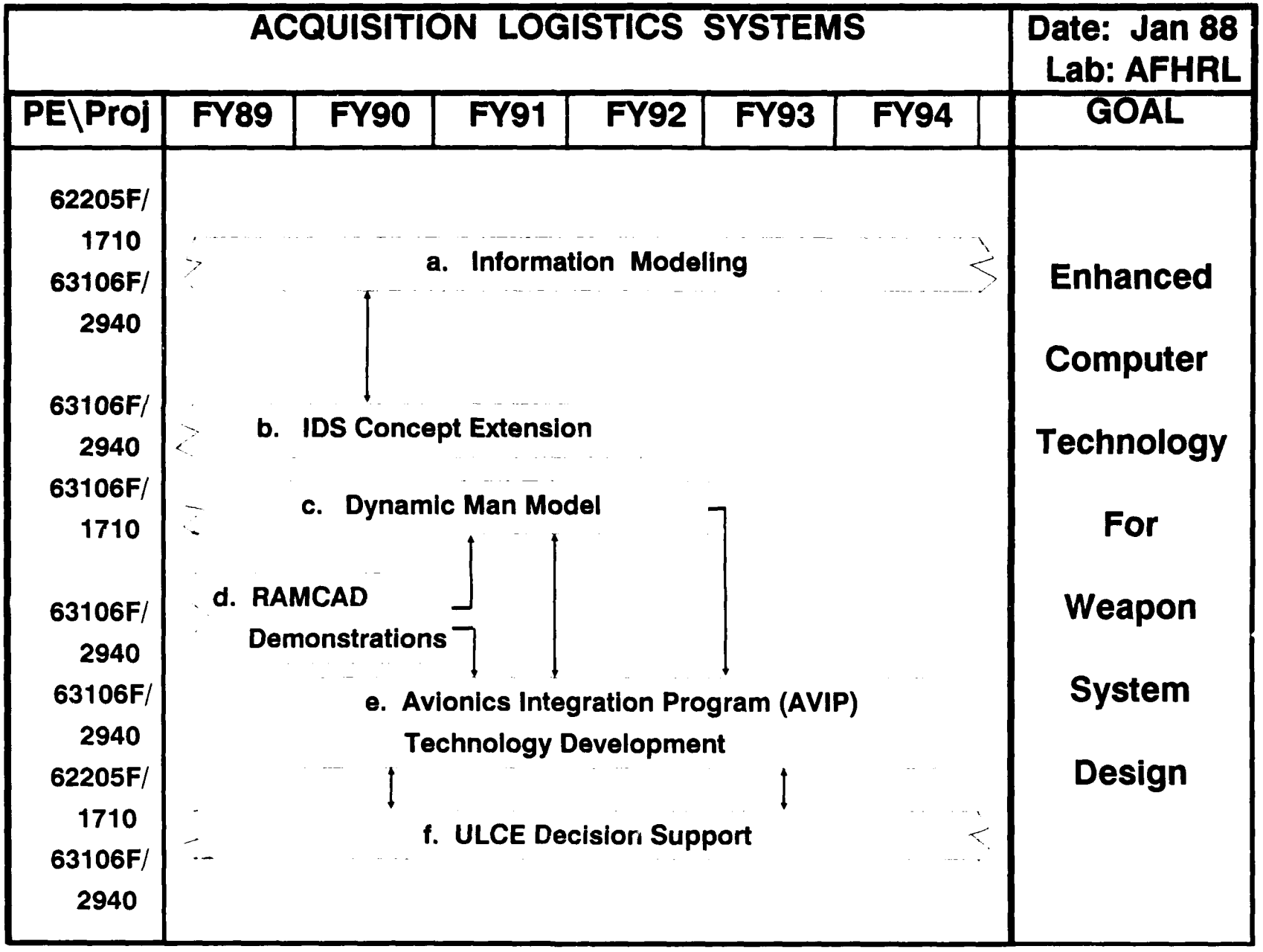

Fig 3. Logistics Technology Subthrust LR-1: Acquisition Logistics Systems.

Computer-aided disign will assist engineers in making tradeoff decisions.

c. Dynamic Man Model. The Harry G. Armstrong Aerospace Medical Research Laboratory (AAMRL) and AFHRL are currently developing a computer graphics model of Air Force technicians for use in evaluating the maintainability of weapon system designs. The model, called CREW CHIEF, will be expanded to perform mockup-type evaluations of new weapon systems and equipment designs. It will encompass both male and female technicians and both standard work clothes and protective equipment. CREW CHIEF will interface eventually with the CAD systems used by aerospace manufacturers and will provide a way of evaluating the maintainability of aircraft. The efficiency and user friendliness of CREW CHIEF will be increased by the integration of the CREW CHIEF data with CAD computer routines to automatically perform task analysis and time breakdown analysis. The Dynamic Man Model (DAMAS) project consists of five major phases: (1) animation (FY88); (2) collision detection/avoidance (FY89); (3) human factors analysis (FY90); (4) activity modeling (FY90-91); and (5) time estimation (FY92).

d. Reliability and Maintainability in Computer-Aided Design (RAMCAD) Demonstrations. This effort will develop analytical models, computer software, data bases, and work procedures for including maintenance and logistics factors in the computer-aided design of systems and equipment. Computer-aided engineering techniques have helped reduce design time, making it possible to consider reliability and maintainability factors during the initial design phases. A wide spectrum of CAD technologies for industrial design are being developed in the commercial market. These CAD technologies substantially enhance drafting capabilities and the hardware design process. Since maintenance and logistics considerations are not formally a part of the drafting process, industry has little motivation to incorporate them into their CAD systems. RAMCAD provides the only USAF funding for such efforts.

e. Avionics Integration Program (AVIP) Technology Development. The objective of the RAMCAD for AVIP technology program is to develop, validate, demonstrate, and transition an integrated durability-oriented electronics design assessment capability for use within the equipment acquisition process. Specifically, this program will provide the techniques for performing durability design assessments in an integrated software environment and support the rapid assessment of proposed designs by a project office, its agents, or an equipment contractor. The RAMCAD for AVIP program is a joint effort between AFHRL and the Air Force Wright Aeronautical Laboratories (AFWAL/FI). Target plan milestones are: RAMCAD integration software (3rd Qtr FY90), software assessment (4th Qtr FY90), and first prototype (FY92).

f. ULCE Decision Support. This R&D is fundamental for a decision support system that will allow a design engineer to systematically perform tradeoffs among numerous competing design parameters. Decision support architecture/integration requirements were completed in September 1987, and provided to RAMCAD contractors. System engineering and measurement efforts began during FY87. Current plans call for a 36-month program focused on examining the problem of multi-criterion RM&S analysis during the design cycle (FY92). A knowledge-based architecture will be defined that gives the designer a highly interactive analysis capability for optimizing design requirements at any level of system assembly (FY94).

2. Integrated Maintenance Information System (IMIS). The Air Force now has or is developing several computer systems for use at base level to support the maintenance and supply functions. Unless they are interfaced, the Air Force will have several incompatible computer systems on the flight line of the future. Incompatible hardware, data requirements, and training needs will cause confusion. IMIS will link existing and developing flight line systems with a computer-based technical information system and will add diagnostic job aids to augment the ability of technicians to troubleshoot. IMIS will provide a limited approach to total weapon system maintenance. Technical data, training, diagnostics, management, scheduling and historical data bases will be linked together. A portable, graphic display job aid will present the required information at the job site. It will interface with on-board aircraft computers and with large computers in the maintenance shops.

The IMIS program is closely coordinated with AFWAL and other Air Force and DOD agencies. Specifications and authoring systems for technical orders in electronic form are being targeted for implementation as Phase IV of the Air Force Automated Technical Order System (ATOS). A major potential application of this technology will be to the Advanced Tactical Fighter. The final products will be validated draft specifications and standards for use by weapon system acquisition program offices.

IMIS will have several benefits: It will improve the use of available manpower, enhance technical performance, improve training, and reduce the support equipment and technical documentation needed for deployment. IMIS also may eliminate the need for the Air Force to field several different computer systems, greatly reducing the need for unique hardware and software. Significant cost savings could be realized from reduced training. Perhaps most importantly, its diagnostic capabilities will allow technicians to troubleshoot faults more rapidly. As a result, aircraft will be restored to operational status more rapidly and fewer spare parts will be consumed.

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Plans for IMIS are outlined in the activity flow chart in Figure 4.

a. IMIS Diagnostics. IMIS diagnostics developmental systems will provide a diagnostic modeling language for describing aircraft system faults, symptoms, tests, and repair actions in FY89. This modeling language supplies the basis for a diagnostic advisory system which, when integrated with the already developed authoring and presentation system, will provide the technician with a complete set of diagnostics and technical order instructions for performing on-equipment maintenance.

b. F-16 Demonstration. An F-16 demonstration field test of the diagnostic aiding system, including a 1553 data bus interactive capability, will be developed utilizing the Portable Computer-based Maintenance Aids System (PCMAS) job aid. Diagnostic models and sample electronic tech data will be developed for a set of F-16 subsystems, and loaded into

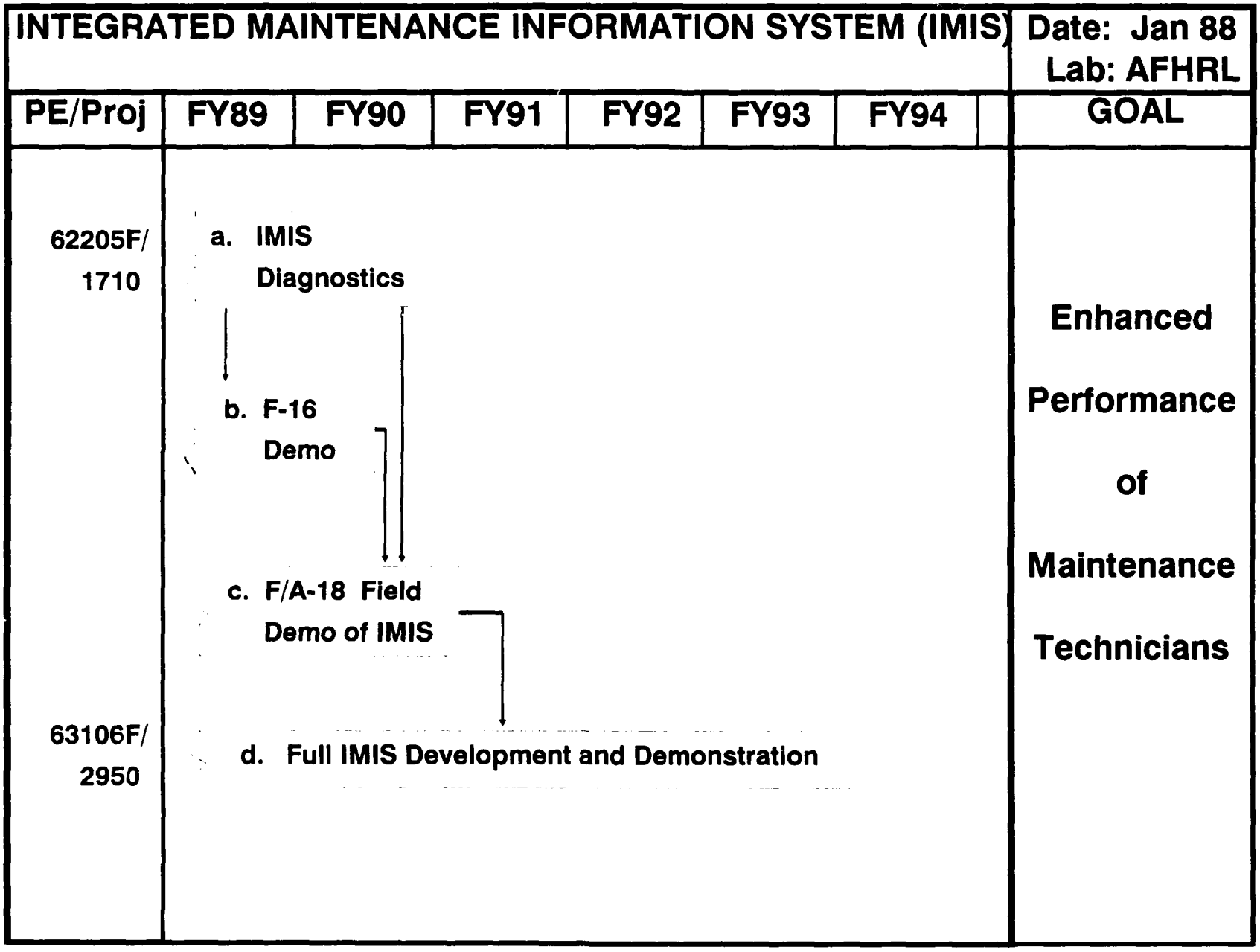

Fig 4. Logistics Technology Subthrust LR-2: Integrated Maintenance Information System (IMIS).

the portable computer. The utility of this system will be tested in a Tactical Air Command (TAC) field test.

c. F/A-18 Field Demonstration. In the F/A-18 field demonstration, AFHRL is working with the Navy to develop and evaluate an on-aircraft interactive diagnostic capability. This work, scheduled for completion in FY90, will be a more extensive test of the systems developed and tested on the F-16.

d. Full IMIS Development and Demonstration. A complete IMIS system that will integrate and display all of the maintenance information important to the flight line technician in future dispersed maintenance environments will be developed and demonstrated during FY89-92. The project will analyze the total information requirements for future maintenance environments, and will develop and field test a complete information system to meet those requirements. The project will produce the functional specifications for the full-scale development of an IMIS system by FY93.

3. Combat Capability Assessment. This R& [illegible] ll improve the readiness and capabi [illegible] of maintenance units to sustain hi[illegible] aircraft sortie rates under wartime cond[illegible]tions. Methods are being developed to determine what tasks are essential to combat and how organizations and procedures differ when they transition from peacetime to combat. Then, the methods and data will be used to develop and demonstrate combat-oriented operating practices and training programs. The effort will use recently completed work on AFSC restructuring and maintenance in a chemical warfare environment.

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Plans for the work in this area are outlined in Figure 5.

a. Combat Data Analysis for AFWAL/FI. The objective of the combat data analysis for AFWAL/FI, scheduled for completion in FY91, is to develop an integrated combat data base using actual and exercise data from both U.S. and foreign sources. The data base can be used to depict actual combat conditions. These data will then be used by analysts and modelers to determine wartime requirements and sortie capabilities.

b. Impact of Stress. AFHRL's stress research will examine the feasibility of various approaches for reducing stress and its job performance impacts in aircraft maintenance organizations. During FY89, several approaches will be evaluated and prioritized based on their cost-effectiveness, implementation feasibility, and probabilities of success.

Training Technology

General Objective

The general objective of training R&D is to develop and maintain enhanced job performance and combat readiness by identifying and demonstrating cost-effective ways of developing and maintaining new skills. These new training strategies and systems will be designed to result in higher quality job performance and increased combat readiness at optimal cost. The improvements in job performance and combat readiness will be designed to reduce early loss rates in combat and increase survivability so there will be more equipment and personnel available for subsequent combat efforts. The improved cost effectiveness will make it possible to train more personnel to these high levels of performance and permit more effective use of the limited training resources that are available for the acquisition and retention of complex combat skills.

COMBAT CAPABILITY ASSESSMENT							Date: Jan 88 Lab: AFHRL
PE/Proj	FY89	FY90	FY91	FY92	FY93	FY94	GOAL
62205F/ 1710	a. Combat Data Analysis for AFWAL/FI						Enhanced Capability For Combat Maintenance Units
62205F/ 1710	b. Impact of Stress						

Fig 5. Logistics Technology Subthrust LR-3: Combat Capability Assessment.

Specific Goals and Technical Approaches

1. Aircrew Simulator Training Requirements. The drive toward lower cost training will be advanced by the application of new simulation technologies and aircrew training systems designs that will permit savings by providing high quality training in cost-effective ways. The most important goals for aircrew training are to identify the amount of simulator fidelity required and to determine the extent to which specialized training should be used to help enhance mission readiness. This information is needed to help designers of Air Force training systems decide, "How much is enough for a given task?" With this objective in mind, priority has been given to seven training requirement issues as part of a Training Effectiveness Plan (TEP) that was agreed upon by AFHRL and the organizations that make use of AFHRL products.

The activities flow chart for this subthrust is shown in Figure 6.

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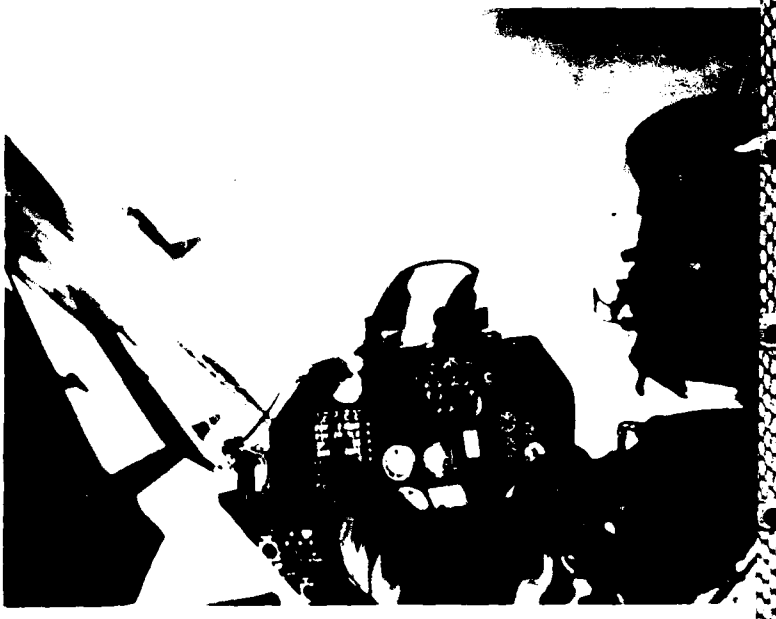
Figure 6 shows the work that was agreed upon when the TEP efforts began in FY84. Follow-on efforts are located in other Training Technology subthrusts (see sections 2 and 3 below). The work remaining in the original TEP is as follows:

a. Training System Design Guidelines. Specifications were developed for total training system design guidelines that will use a spectrum of training media, and integrate all phases of training from "cradle to grave." Military Airlift Command (MAC) and AFHRL have incorporated these concepts into the C-130 Aircrew Training System (ATS). The program includes an evaluation of the ATS and its major elements as well as an R&D component to address performance measurement, instructional strategies and cost/benefit issues in the context of the C-130 ATS. Similar programs are being developed for the B-52/KC-135 formal school. Collectively, these programs will contribute to guidelines for designing training systems courseware that fully use the capabilities of a given training device, integrate differing media in cost- and training-effective ways, and can be used to design total training systems to coordinate all phases of training. A comprehensive report describing lessons learned and findings from this progress will be published in FY92. The report will be much broader in scope than originally envisioned in the TEP and the training guidelines should be useful in a wide variety of aircrew training systems as a total training systems design manual.



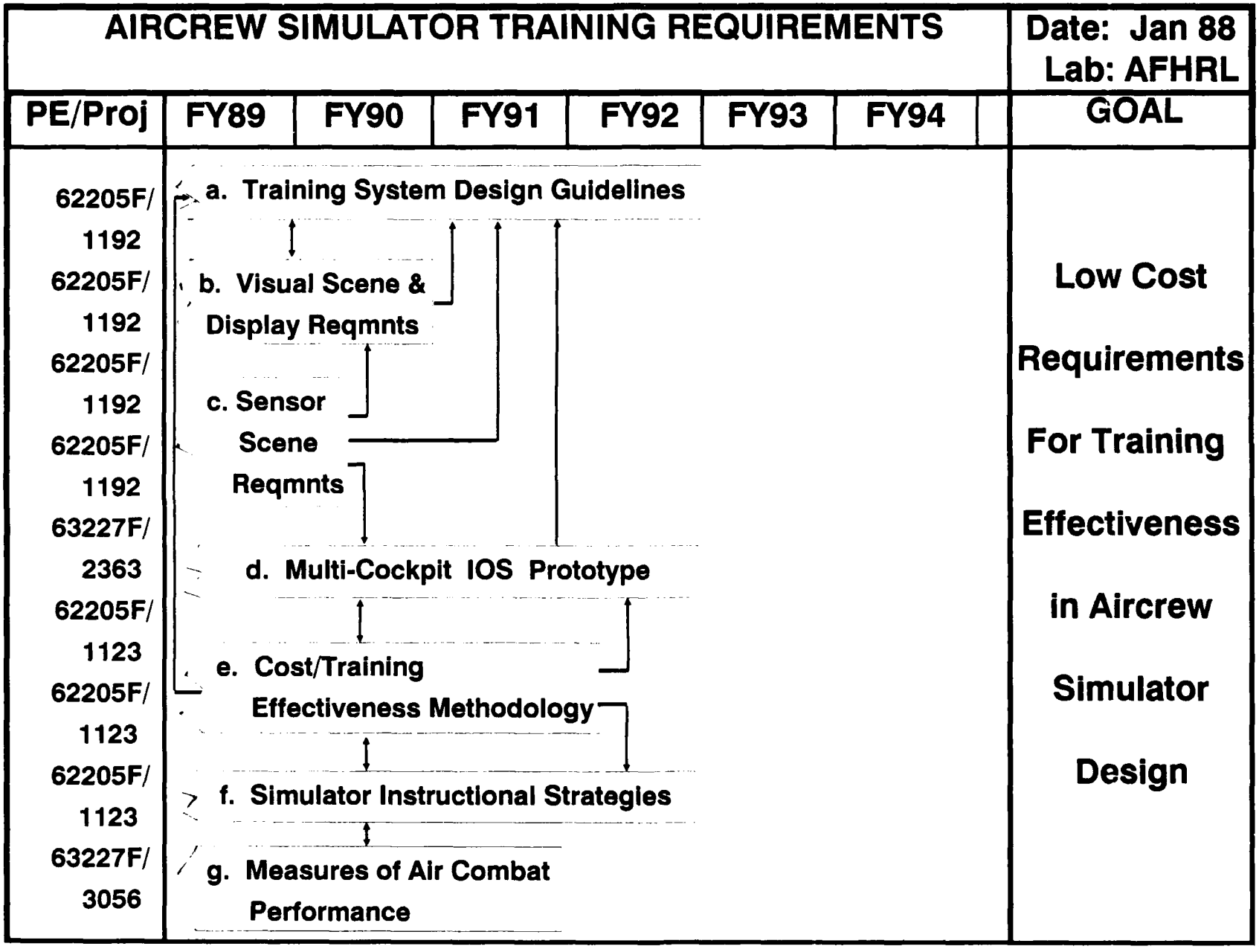


Fig 6. Training Technology Subthrust OT-1: Aircrew Simulator Training Requirements.

b. Visual Scene and Display Requirements. Additional efforts will be conducted in the visual fidelity area during FY89 - 90. During FY89, work will be completed on: criteria for tactical simulator display brightness; criteria for simulator display resolution; specifications of requirements for various levels of target detail; and a handbook of visual scene requirements for training low-level flight skills. This handbook will be partly based upon the performance of Air National Guard students in a variety of visual scene conditions (different textures, 2- and 3-dimensional object types and densities, sizes of objects, shadings, shadows, and atmosphere attenuation will be explored). During FY90, a supplemental report will be completed containing recommendations for the use of color in flight simulation.

c. Sensor Scene Requirements. During FY89, studies of infrared and radar image fidelity will be conducted. One set of studies will evaluate the ability of subjects to determine basic characteristics of ground targets, such as orientation and classification, as a function of sensor image fidelity. Another set of studies will determine the simulated infrared scene fidelity needed to train low-altitude terrain-following and navigation tasks.

d. Multi-Cockpit IOS Prototype. During FY89 - 92, work will be conducted on multi-cockpit Instructor Operator Station (IOS) designs and modular IOS software. The multi-cockpit IOS will be capable of interfacing with eventual prototype configuraticns on an in-house, 2- to 4-cockpit simulator by FY92. The modular software (developed in FY90 as part of a joint Service program) will be a standard IOS software package applicable to aircrew simulation training in general.

e. Cost/Training Effectiveness Methodology. This issue is primarily concerned with the design and implemention of a data base that can be used to consolidate existing information about cost/training effectiveness relationships and make it available when cost tradeoff decisions must be made. Most of the work in this area is being conducted by the Army Research Institute (ARI) and the DOD Training and Performance Data Center (TPDC). ARI has been developing a model for the Optimization of Simulation Based Training Systems (OSBATS) since FY86. AFHRL is providing data for use in testing this model. Although OSBATS is not yet complete, the model is expected to furnish a comprehensive way of estimating the cost/training effectiveness of aircrew training simulators in FY89. The computer model, when fully refined, will provide a way of determining optimum points on the simulation cost-versus-fidelity curve. TPDC is responsible for incorporating training effectiveness data into TPDC data bases when the data are ready for this transition.

f. Simulator Instructional Strategies. The objective is to design instructional techniques that will increase skill retention, optimize feedback, and generally help Air Force instructors to conduct training in an effective manner. In FY88 - 89, this program will focus on defining the requirements for training multi-ship situational awareness. In FY90, training benefits as a function of pilot skill level will be addressed. Planned efforts include: a skill acquisition and retention data base (FY90); guidelines for optimizing feedback (FY92); and guidelines for the construction of combat training syllabi (FY92).

g. Measures of Air Combat Performance. The objective is to validate and refine techniques for assessing air combat performance using the Air Combat Maneuvering (ACM) Performance Measurement System (PMS) developed for the Simulator for Air-to-Air Combat (SAAC) and the Air Combat Maneuvering Instrumentation (ACMI) range. The R&D will identify and implement alternative scoring techniques and collect data that reflect the relative validity of these alternative scoring procedures. Upon completion of the

Air-to-Air PMS, work will be continued to include an Air-to-Ground PMS. The end product in FY91 will be a valid set of techniques and procedures for measuring air combat performance.

2. Aircrew Training Technology Development. The mission of AFHRL includes the design, development, and evaluation of new methods, equipment, and simulator devices for use in aircrew training.

Several efforts are planned in the subthrust, as illustrated by the activity flow chart shown in Figure 7.

a. Part-Task Training Methods and Decision Support Systems. The practice of subdividing complex flight tasks into various parts is a logical way of presenting the student with a task that is, at the outset, not too difficult to master. By this rationale, the larger or more difficult the task, the greater the advantage of part-task training. The critical requirement in designing part-task training is to select effective strategies for partitioning the task for part practice, then later to reintegrate the parts into the whole task. AFHRL R&D has focused upon task partitioning strategies (e.g., simplification, fractionization, segmentation) in designing the PTT system; the need for and importance of performance measurement capability as opposed to simple practice devices without performance measurement; and ways in which computer-assisted instruction techniques can be used to facilitate the part-task training process. In FY89 and FY90, studies will validate the various methods of partitioning tasks that have already been developed and demonstrate PTT devices in different MAJCOM settings. A decision support system for use by PTT system designers will be developed in FY92, and the information on the use of computer-assisted instruction techniques will be pulled together and integrated into a users guide for Part-Task Training devices in FY93. Following this, some advanced work will be conducted on the networking of interactive, low-cost multi-person aircrew training devices in FY94.

b. Combat Crew Training School (CCTS) Modernization. A thorough review and analysis of Air Force B-52 and KC-135 formal school training requirements will be conducted in order to prepare a detailed functional design specification for the training conducted at the B-52/KC135 CCTS. The modernized program will provide for the effective use of existing training media and the optimal mix of academics, ground trainer, and flight instruction required to produce combat-ready aircrews. Included within the total training system design will be the definition of a computer-based subsystem to support program development and maintenance, instructional delivery, performance evaluation, and total training system management (FY89).

c. Total Training Decision Systems. This effort will continue the work on total training systems that was conducted for the C-130 ATS as part of the Aircrew Simulator Training Requirements thrust (see Figure 6). Beginning in FY93, AFHRL will develop an expert system that can be used to facilitate decisions about total training systems design, management, and delivery. One testbed for evaluating the model will be the integration of electronic combat training into the total aircrew training

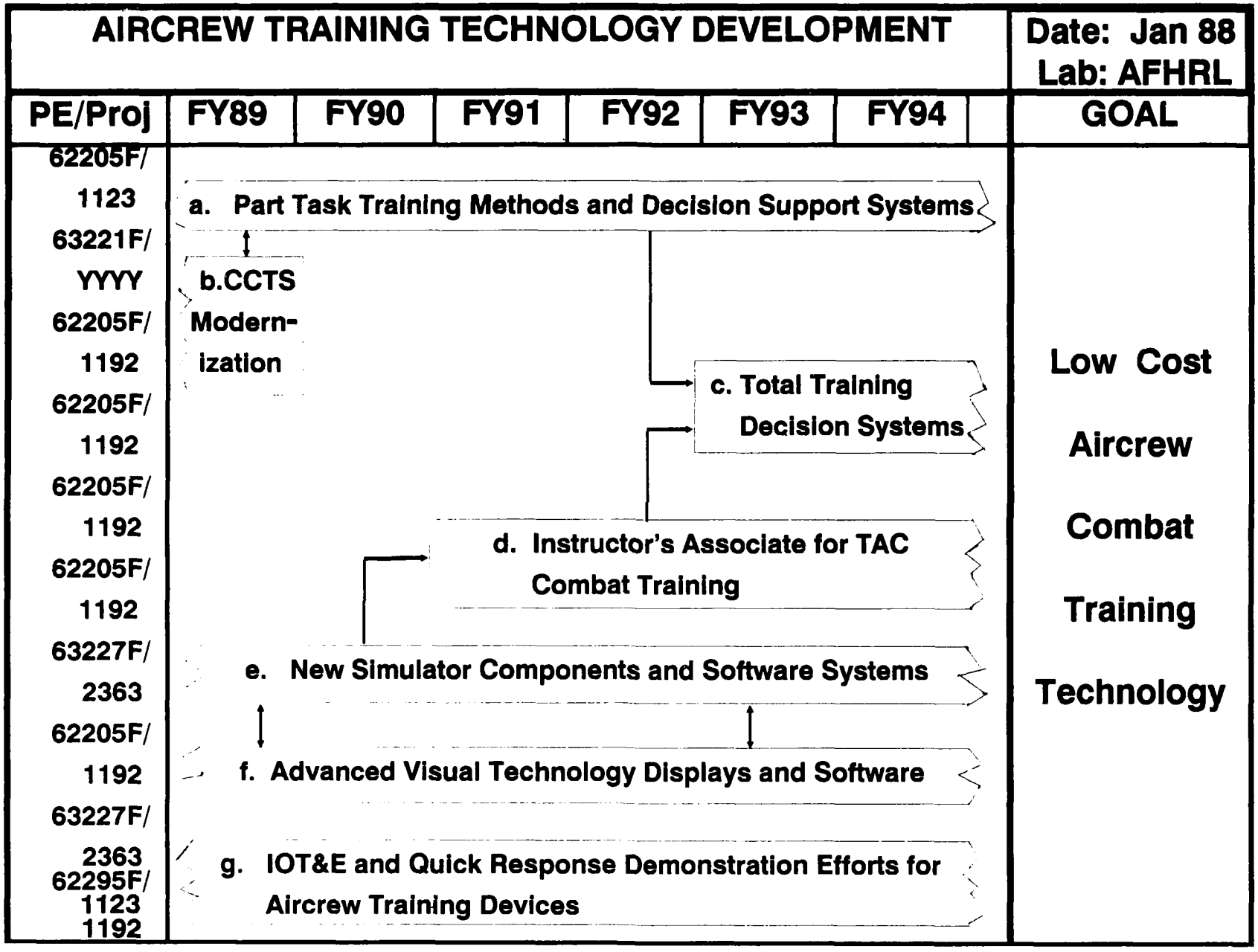
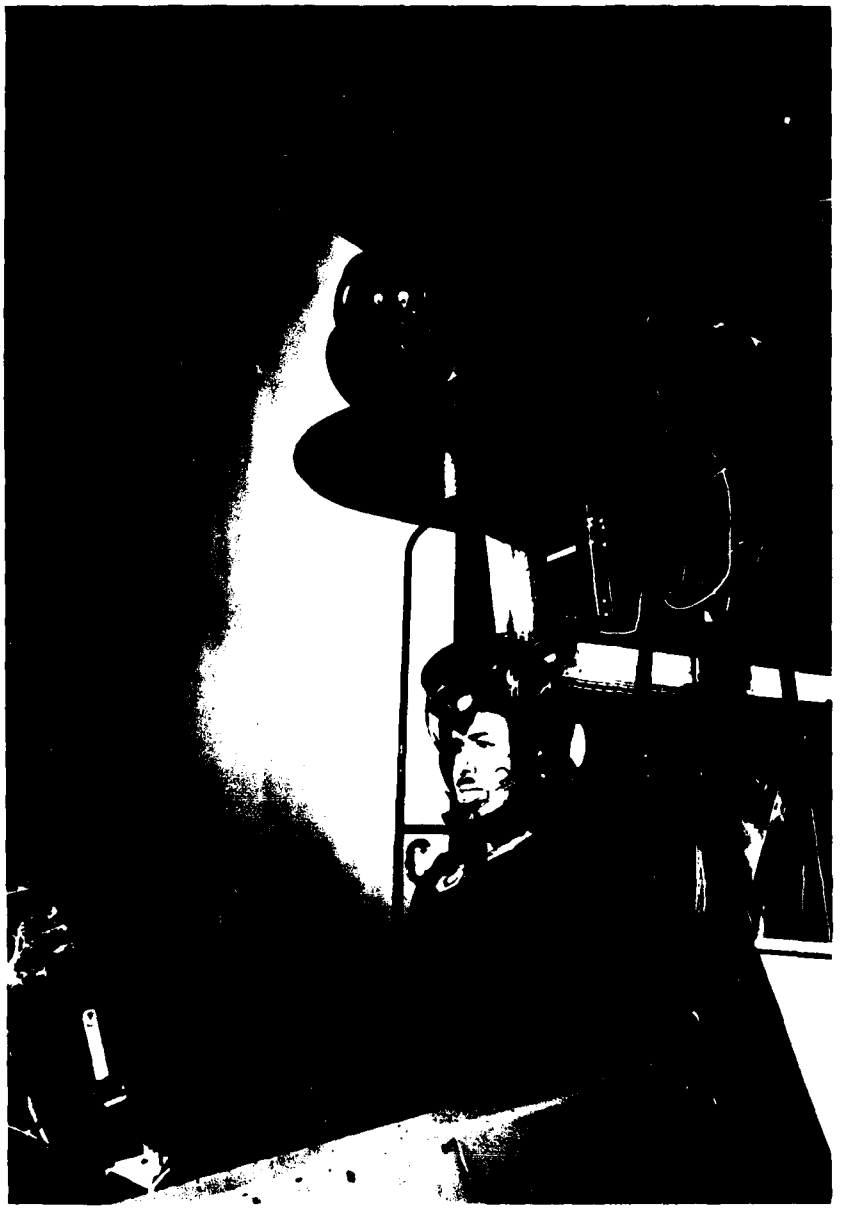


Fig 7. Training Technology Subthrust OT-2: Aircrew Training Technology Development.

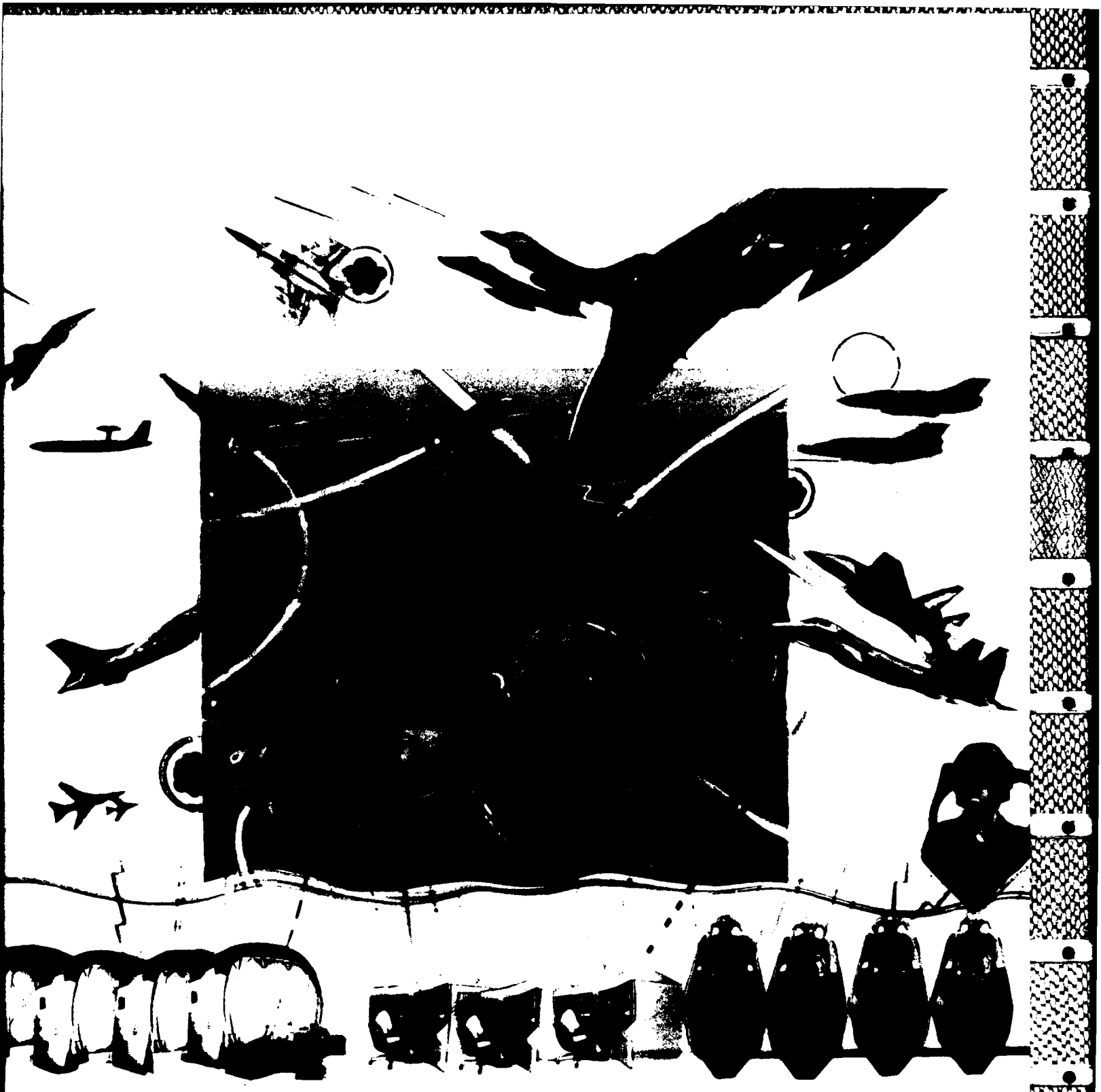
system for selected aircraft. Decision algorithms and tables that can be used to evaluate decision options will be an important part of this new decision system.

d. Instructor's Associate for Tactical Air Command (TAC) Combat Training. This R&D will continue the work on total and multi-ship IOS design that was conducted as part of the Aircrew Simulator Training Requirements thrust. The Instructor's Associate will provide instructors with evaluations of student performance and computer assisted recommendations regarding what kind of instructional strategy to use next. The Instructor's Associate will carry the IOS work one step further by converting complex guidelines into simpler recommendations, and by explaining to the instructor why one training system or technique is thought to be better than another. It should consequently be useful in training new instructors in the use of sophisticated feedback procedures and instructional strategies (e.g., instant replay, freeze, segmentation or fractionation of instruction) that are not always used as often as they should be because instructors are not accustomed to them.



The Advanced Visual Technology System is a real-time Computer Image Generator which supports multiship combat simulation with ten high quality video channels.

e. New Simulator Components and Software Systems. New simulator components and software systems to be investigated are: (a) the use of non-linear focal length projection systems that will compress picture elements (pixels) near the center of the visual fixation point (FY89); (b) a thermal model to assign "gray shades" to portions of an infrared computer-generated image based upon environmental conditions so that forward looking infrared (FLIR) sensors can be simulated (FY89); (c) new computer architectures that will make effective use of multiple microprocessors and parallel pipeline processing systems (FY92); (d) a universal imaging system data base that can be used for many different kinds of out-the-window, infrared sensor, and electro-optical television (TV) displays (FY92); (e) field deployable image generators (FY93); and (f) a variable acuity lens that would provide maximum effectiveness and minimum weight when used in conjunction with non-linear projection



The near-term objective of the Aircrew Combat Mission Enhancement (ACME) project is to provide advanced, cost-effective simulator technology for combat situational awareness and team training, mission rehearsal, and mission planning systems for tactical aircrews.

systems (FY94). The variable acuity lens will permit research on the training requirements for non-linear data bases and projection systems.

f. Advanced Visual Technology Display and Software Systems. An Advanced Visual Technology System (AVTS) project was established in 1978 in order to develop and evaluate new concepts in visual technology systems. The project, which is still active, is oriented towards improved computer image generation (CIG) as well as improved visual display technology. Planned upgrades of the AVTS include providing the capability to fly two eye-tracked displays in independent aircraft within the computer-generated scene (FY89). Another important objective of AVTS is a full field-of-view (FOV) dome display system, which is a joint effort involving AFHRL and the Aeronautical Systems Division (ASD/YW). As a result of this effort, a prototype full FOV dome display system for the F-16 will be integrated with the Advanced Visual Technology System's computer image generators. Once this system is operational (FY89), AFHRL and ASD scientists and engineers will evaluate its training utility for tactical flight simulation (FY91).

g. Initial Operational Test and Evaluation (IOT&E) and Quick Response Demonstration Efforts for Aircrew Training Devices. The Operations Training Division (AFHRL/OT) regularly provides consultants for the IOT&E of new training systems and quick response demonstration efforts. These are important services for AFHRL as well as for its customers, since AFHRL scientists and engineers get important insights into operational needs and problems as a result of their participation in such studies. These IOT&E and quick response studies for new aircrew training systems will continue throughout the planning period.

3. Aircrew Combat Mission Enhancement (ACME). ACME is a Forecast II technology for which AFHRL is the lead organization. Forecast II is an AFSC-wide program to develop 39 technologies and 31 advanced systems concepts that will revolutionize the way the Air Force carries out its mission in the twenty-first century, hopefully guaranteeing continued technological supremacy over any potential adversary. The objectives of ACME (see Figure 8) are to provide cost-effective simulator technology for use in situational awareness training, and specific mission rehearsal practice sessions for tactical aircrews. This technology would be provided by: expediting the development of high-resolution, multi-spectral, geographic gaming areas; expediting the development of very high speed integrated circuit (VHSIC) based computer systems that allow increased simulation capability while significantly reducing size and cost; developing the helmet-mounted display and technologies with multi-participant networking required to support simulation of tactical combat tasks; designing situational awareness training (SAT) systems for use with long distance as well as local area networks; and integrating diverse technologies to define combat mission training, mission rehearsal, and mission planning systems for high-threat environents. Other organizations working with AFHRL/OT and in the conduct of ACME are: AFWAL/AAAT, AFWAL/FIGR, Rome Air Development Center (RADC/IRRP), AAMRL/HEA, ASD/YW, and AFHRL/LR.

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a. Team Training and Situational Awareness R&D. A vigorous program of behavioral research will address training effectiveness issues associated with the situational awareness training system that ACME is designed to develop. Specific R&D issues to be addressed are: the amount and kind of performance measurement and feedback that should be provided; the possible use of expert systems to advise the pilot trainee about preferred strategies and next steps; the acqui-

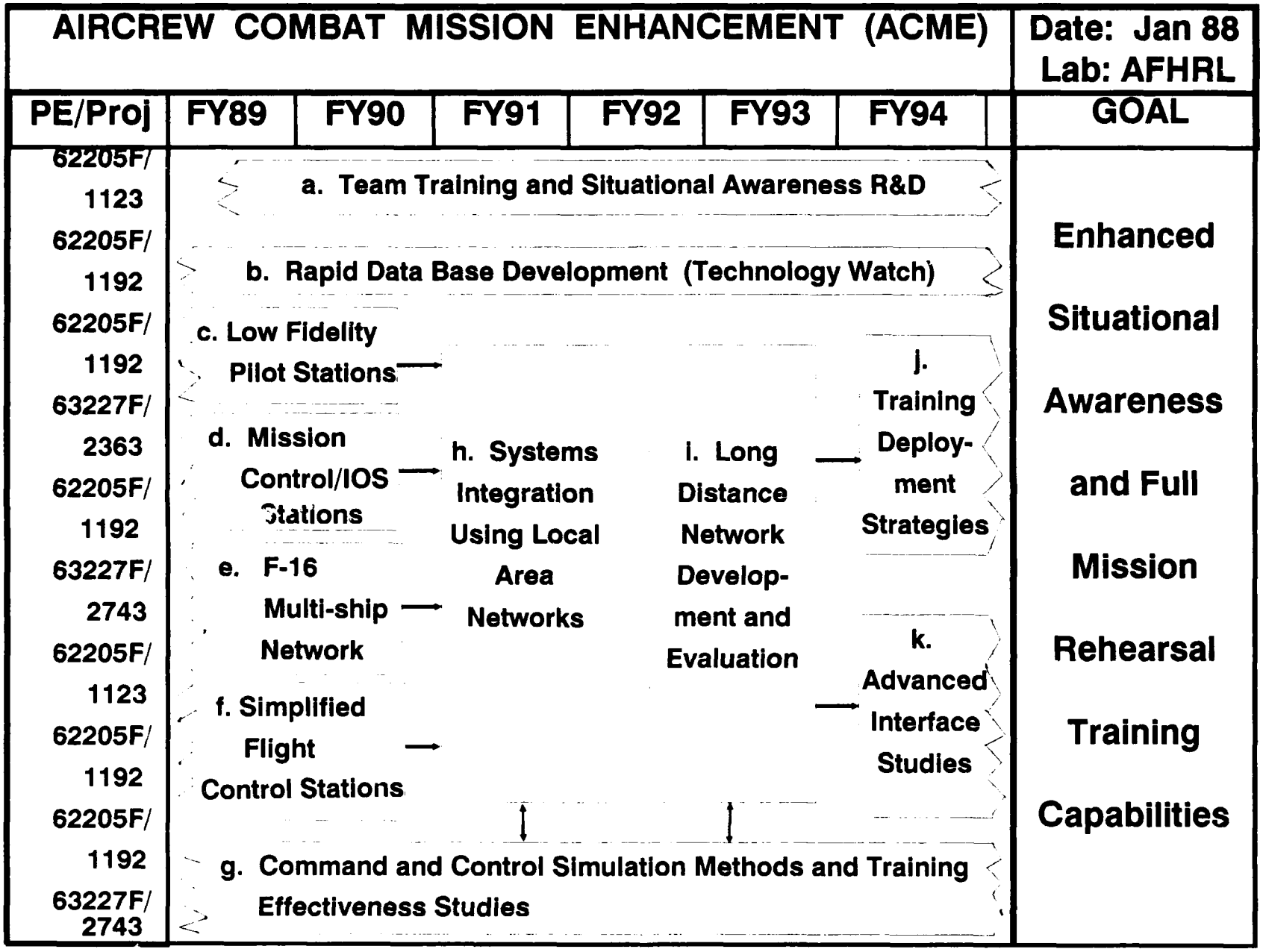

Fig 8. Training Technology Subthrust OT-3: Aircrew Combat Mission Enhancement (ACME).

sition and decay of skills under various equipment and software options; preferred instructional strategies; the preferred complexity of scenarios at various stages of training; motivation and regard features of instructional systems; changes in training techniques and schedules that would facilitate team training; the amount of situational fidelity and component fidelity that results in the most cost- and training-effective results; experimental evaluations of ACME training systems at various stages in their development; and fidelity requirements for sensor imagery and visual systems. During the period FY89 - 91, priority will be given to team training R&D, since the multi-cockpit team training aspects of ACME are relatively unknown. The high-priority R&D area in FY92-94 will be advanced situational awareness R&D.

b. Rapid Data Base Development. The most important requirement for mission rehearsal is likely to be waypoint and target familiarization. This, in turn, requires the development of highly detailed and accurate digital data bases for use by the multi-spectral image generator. Moreover, it seems essential that these data bases be constructed in a relatively short period of time; e.g., 24 hours. The capability to develop such high-resolution data bases with attributes necessary for infrared and radar simulation in such a short period of time is well beyond the current state of the art. Fortunately, this problem is being attacked by a variety of industrial and Government sources. The most important effort for ACME at the present time is project 2851, which is a tri-Service effort sponsored by the Joint Logistics Commanders. The objective is to develop a DOD standard data base and common transformation software that will be used for simulator training devices requiring the use of digital cartographic data. AFHRL will maintain a close technology watch on these efforts and incorporate useful information into the design of ACME systems as it becomes available.

c. Low Fidelity Pilot Stations. As ACME develops, there will be a spectrum of devices connected to the network. Some of these will be high-end full-fidelity simulators; some will be medium-fidelity simulators, such as fairly faithful cockpits (with some wallpapered instruments) and a small dome; and others might be quite austere simulators such as the F-16 Part-Task Training (PTT) system which has a few cathode-ray tube (CRT) displays and accurate throttle and joystick. ACME could conceivably make use of low-cost consoles that allow players to fly adversary (red force) aircraft, to fly friendly (blue force) aircraft, and to deal with manned (or perhaps unmanned) threats such as surface-to-air missiles (SAMs) and anti-aircraft artillery (AAA) missiles. Use of simplified stations will increase the number of participants while keeping costs associated with additional players low. Exploratory evaluations of consoles of these types will be conducted during FY89-90.

d. Mission Control/IOS Stations. The Multiship Instructional Support System for ACME (MISS ACME) addresses the instructional requirements for the situational awareness training system. It will provide an initiation, control, measurement, briefing, and debriefing capability for the situational awareness training system. Envisioned capabilities of MISS ACME include: scenario generation and control, whereby the initial conditions are programmed and battle engagements are initiated; real-time acquisition of data as the data are passed over the network; real-time scoring and assessment of the engagement; on-line display of mission progress using large screen projection techniques and post-mission debriefing and analysis. MISS ACME shall be initially designed to support up to 14 players on the local network system. MISS ACME will be a jointly shared program with ASD/YWB, and will also support the requirements for a generic IOS.

e. F-16 Multi-Ship Network. The initial multi-ship network will be developed on a local area basis using F-16 communications as a model. The F-16 multi-ship network will also be used for other kinds of R&D, as shown by its experimental components. One cockpit will use the limited field-of-view (FOV) dome display; one, the full FOV dome display. Two will use Fiber-Optic Helmet-Mounted Displays (FOHMDs); one will use the variable acuity projection system dome display. Other major elements in the F-16 multi-ship part-task trainers currently being developed for the F-16 are: four simplified flight control stations which permit additional participants to use graphic display systems for the pilot/generator interface; a modular threat simulation system which generates all of the ground threats and provides electronic warfare algorithms for use in a real-time flight simulation combat environment; and a mission control station to provide for the control, measurement, mission planning, briefing, and debriefing functions of the situational awareness training complex. The final element and the most crucial one to the success of the effort is the networking system. The approach is to develop a local area network using a standardized communication protocol. All communication among the various elements of the Situational Awareness Training (SAT) complex shall be through the network. It is expected that the individual components of the SAT complex will be completed by FY90 and that integration will be accomplished by FY91.

f. Simplified Flight Control Stations. Combat training simulator networks have a requirement for low-cost, simplified "player" stations to provide adversary "red" forces to fight against, and supplemental "blue" forces. Since some of these "players" are not actually in training, the flight control stations can be greatly simplified. Stations of this type will be designed and evaluated as part of the ACME program during FY89-90.

g. Command and Control Simulation Methods and Training Effectiveness Studies. Command posts are an important part of any combat simulation, and cannot be ignored during situational awareness training. During FY89-92, work on the situational awareness training requirements for small operations (involving only a few aircraft) will be conducted. This will be expanded in FY92-94 to include studies of large-scale operations involving Tactical Air Control Centers (TACCs) and Allied Tactical Operating Centers (ATOCs) (See Figure 9).

h. Systems Integration Using Local Area Networks. During FY90-92, a number of ACME components will be integrated, and the best approaches will be selected. Evaluative studies will be initiated on integrated combat simulators that are capable of providing situational awareness training to a small group of pilots at the same time, using a local area network to provide some of the interactions between pilots, their controllers, opponents, and simulated friendly forces.

i. Long Distance Network Development and Evaluation. The local area network system will be expanded into a long distance network in FY92-93, since the state of the art is expected to permit that kind of advance at that time. This will permit pilot trainees in one part of the world (e.g., U.S. Air Forces in Europe (USAFE)) to challenge experts in another part of the world (e.g., the Red Flag training staff at Nellis AFB) without leaving their home base.

j. Training Deployment Strategies. During FY94, ways of deploying the ACME training systems will be examined from a cost effectiveness point of view. Simplification and weight reduction options will be considered and evaluated.

k. Advanced Interface Studies. During FY94, a number of advanced interface studies will be conducted with the objective of expanding the scope of the

ACME training system to include Navy and Army forces. Work will also be conducted to evaluate the use of these expanded simulation programs to evaluate wargaming options and to study the conditions under which the development of creative solutions to combat problems is facilitated by the use of training simulator devices.

4. New Concepts in Aircrew Training Systems. Although they have not yet been organized into thrusts, new concepts in aircrew training systems are being developed at the Operations Training Division as a result of exploratory and advanced development studies.

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Important probe studies are: artificial intelligence applications and embedded training systems.

a. Artificial Intelligence (AI) in Aircrew Training. The initial goal in the artificial intelligence area is to establish a knowledge base of pilot combat skills for use in aircrew training. It will include the areas of air-to-air, air-to-ground, and threat evasion techniques. AI will be used to break up tasks and develop part-task trainers that will use AI to optimize instruction and model performance. Information on tactics and execution will then be incorporated into expert knowledge data bases for use in full mission simulator training exercises. A generalized AI model for use in part-task trainers will be developed in FY90. Expert systems for use in full mission simulators will be demonstrated in FY92.

b. Aircraft Embedded Training Systems. AFHRL will conduct work on a number of equipment-integrated systems in which on-board simulators (OBS) are used for training. One of these, being developed by AFWAL/FIGX, is a new and improved Integrated Flight Fire Control (IFFC) system called Integrated Control Avionics for Air Superiority (ICAAS). The systems to be developed for ICAAS will permit use of embedded training systems designed and evaluated at AFHRL. Working jointly with AFWAL/FIGX, ASD/YWB and ASD/ENET, AFHRL will develop specific training programs (prior to FY90) for: friend vs foe recognition; multiple target decisions; and team attack.

5. Aircrew Training Research Support Contracts. All of the aircrew training efforts are supported by three research support contracts. Two contracts of this type provide operations, maintenance, and programming support for Digital Image Generators (DIGs), display systems, cockpits, and consoles. These contracts are competed every 5 years, with the next round of competition scheduled in FY92 for a contract start in FY93. Another research support contract is used to provide quick response technical and programming support for in-house and contractor R&D efforts. This contract is normally competed every 3 years. Rounds of competition during the FY89-94 timeframe are tentatively scheduled for FY89 and FY92.

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6. Command and Control (C^2) Systems Analysis and Training. The evolution of the C^2 function in the Air Force is increasing both the challenge of training C^2 teams and the payoff of such training. Future C^2 systems will involve a network of interdependent nodes; if some nodes are destroyed during combat, other nodes will have to assume their functions. So, C^2 teams will have to be trained to perform a wide range of functions. In addition, the complexity of battle management will increase. With this increase come additional requirements to provide both realistic combat training opportunities and system design guidance to ensure that man-machine interaction requirements/design support these increased operational demands.

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Figure 9 summarizes AFHRL's planned C^2 program.

a. Training for Decision Making. This continuing effort involves acquiring the decision making knowledge of expert battle managers through knowledge engineering and using it to construct a computer-based learning environment for training higher level decision-making skills. A prototype training system will be completed in FY89.

b. Part-Task Trainers for High Performance Skills. AFHRL is developing a new generation of part-task trainers based on an application of automated information processing principles to high performance C^2 skills. Research on skill retention, workload reduction, and transfer will be accomplished in FY89. A prototype part-task trainer for C^2 skills will be built in FY90 and evaluated during FY91.

c. Training for Functionally Distributed Systems. This R&D uses wartime simulations like TACTHUNDER to access the decision making of individuals and teams under functionally distributed systems. Team effectiveness and decision making under proposed C^2 configurations will be investigated. Later, this effort will be linked to the Aircrew Combat Mission Effectiveness (ACME) program, which will allow emulation of an actual Control and Reporting Center (CRC). TACTHUNDER studies of alternative C^2

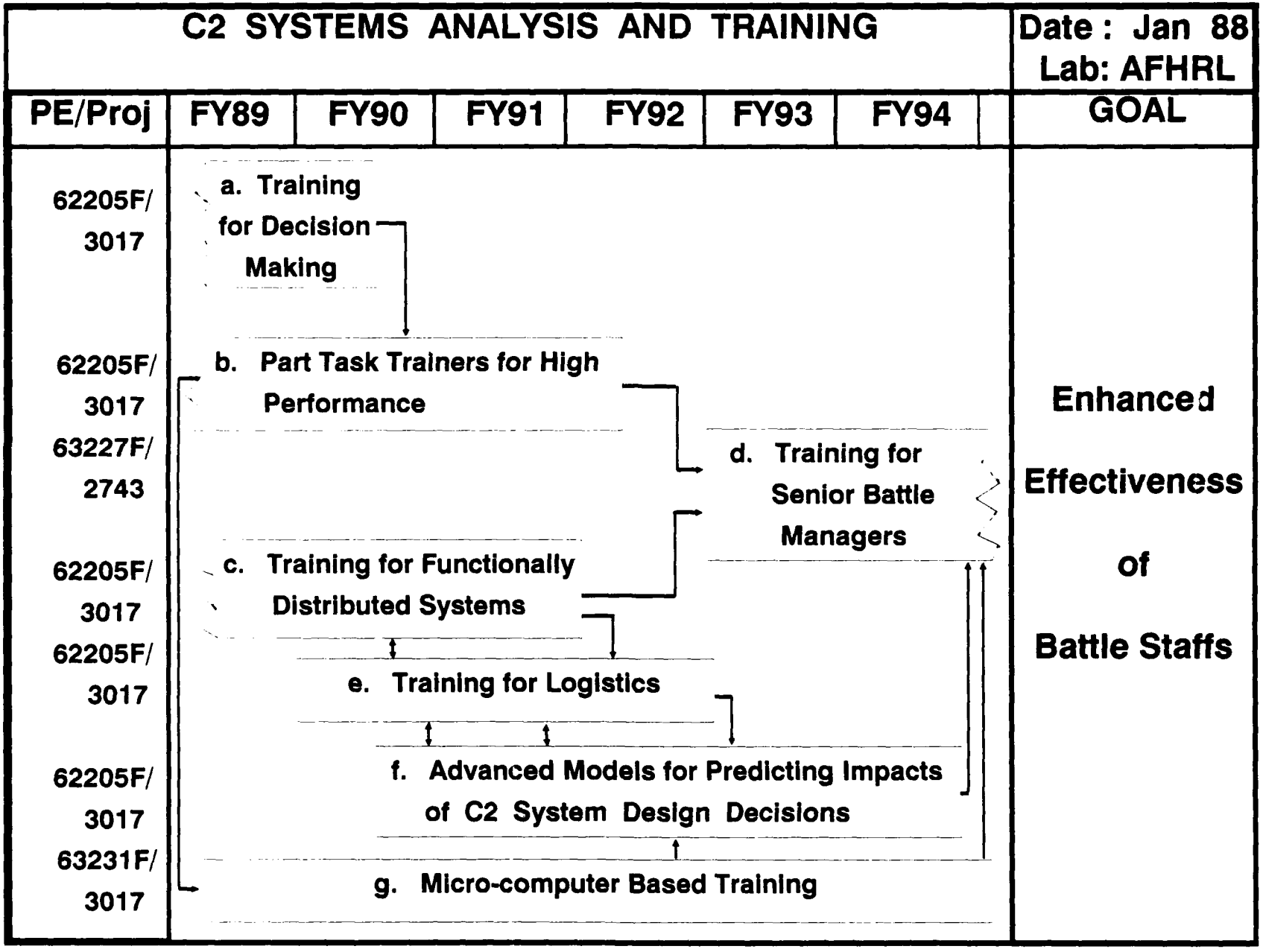

Fig 9. Training Technology Subthrust LR-4: C2 Systems Analysis and Training.

configurations will be completed in FY90. The initial link to ACME will be established in FY90 and evaluated during FY91.

d. Training for Senior Battle Managers. Beginning in FY93-94, the work on high performance skills part-task trainers and on training for functionally distributed systems will be brought together to build a training system for higher level battle managers.

e. Training for Logistics C^2. The goal is to develop knowledge-based training in decision making for logistics battlestaffs. The system will provide training at peacetime duty stations and will give novices exposure to the complex decisions and variables associated with wartime logistics. Development of an expert knowledge base will be accomplished in FY90 and evaluated during FY91-92.

f. Advanced Models for Predicting Impacts of C^2 System Design Decisions. This effort will be initiated in FY90 and will expand and refine methods for assessing the impact of automation on tactical C^2 systems. It will provide a predictive model of the multifunctional, highly interactive, expert decision-making environment of a Tactical Air Control Center, by FY93.

g. Microcomputer-Based Training. This activity integrates the technologies developed under the 6.2 program in training for battle management and focuses on training the Modular Control Equipment (MCE) teams. It will emphasize job familiarization, decision making using knowledge-based simulation, and team training. System requirements analysis will be completed in FY90.

7. Technical Training Design and Delivery. The Air Force could have a technical training gap in the future. New weapon systems and new war-fighting tactics will increase both the number and the complexity of the tasks that airmen must master. But, training resources are unlikely to grow. A technical training gap can be avoided only if training resources are used more effectively. Since the computerized management and delivery of training could increase the efficiency of Air Force technical training, AFHRL has made them the major focus of its technical training R&D program.

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Figure 10 summarizes how AFHRL plans to help make computerized training a more efficient and effective tool for the Air Force.

a. Advanced On-the-Job Training System (AOTS). This effort has developed a prototype system for managing, delivering, and evaluating on-the-job training. The R&D will conclude in FY89 with a field test and evaluation of the prototype system.

b. Computer-Based Training (CBT) Design and Delivery Development. This activity will make AFHRL's CBT expertise available to the Air Force in a number of useful forms. A succession of products is planned, including: (1) a CBT handbook to assist users in developing high quality computer-aided instruction; (2) findings on the effectiveness of CBT as an instructional medium; (3) evaluative criteria for selecting a CBT system; (4) a testbed for evaluating the capabilities and limitations of new CBT systems; and (5) prototype software

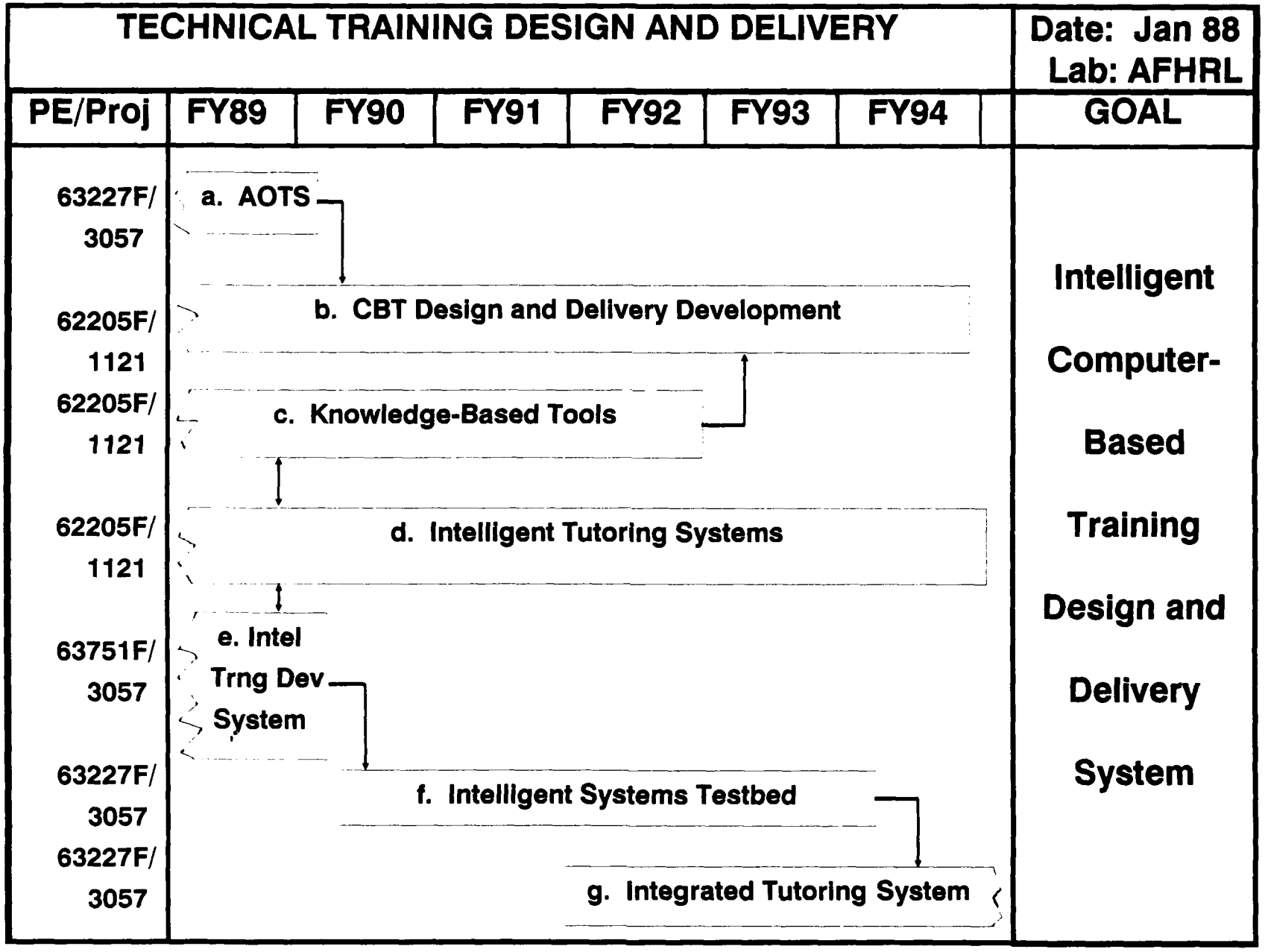

Fig 10. Training Technology Subthrust ID-1: Technical Training Design and Delivery.

that can recommend the most effective and efficient CBT system to meet a set of training requirements. The work will run through FY94.

c. Knowledge-Based Tools. The building of the first intelligent tutoring systems (ITS) has shown that drawing out expertise from experienced practitioners in a field is an expensive process. The costs of the so-called "knowledge engineering" process will have to be cut if intelligent tutoring systems are to become widely used in the Air Force. This effort, which is sponsored jointly by the Army Research Institute, the Naval Training Systems Center, and AFHRL, aims to bring down the costs of building ITSs. It will do so by developing software tools that will allow expert practitioners with minimal instructional design and computer programming skills to develop a key component of an ITS--the student module. The work will be completed in FY91.

d. Intelligent Tutoring Systems. This effort will use both AFHRL and contractor personnel to develop a succession of ITSs for Air Force applications. The ITSs will be used to find out what kinds of instructional strategies and student interfaces are most effective for ITSs and what kinds of ITS applications have the highest payoffs. An intelligent gaming instructional strategy will be developed and evaluated by late FY89 and an ITS for space operations will be completed in FY90.

e. Intelligent Training Development Systems. AFHRL has been acquiring the software tools necessary for an excellent program in intelligent tutoring systems; the process will be complete in FY89. The software tools will permit development of ITSs that share the same knowledge domains but differ in important structural ways.

f. Intelligent Systems Testbed. This work will deliver a proof-of-principle prototype system for rapid development of ITSs and empirical evaluation of instructional strategies for ITSs. Called Rapid Prototype ITS Development System (RAPIDS), the system initially will be developed to run on a Xerox 1186. If the initial version is successful, a version that would run on a standard Air Force microcomputer will be developed. The activity will yield not only RAPIDS but also empirical results about the effectiveness of different instructional strategies for ITSs.

g. Integrated Tutoring System. The rapid development of ITS technology is being paralleled by the rapid emergence of interactive visual training technologies. Once ITS technology matures, it will be possible to link it with interactive visual training technologies to develop a "super tutor."

8. Technical Training Management Systems. The planning, implementation, and operation of systems for technical training involve many iterative decisions. Making these decisions requires resources. Moreover, how well the decisions are made can have large impacts on the efficiency and effectiveness of the technical training systems.

Decision support systems consist of computerized job aids for decision makers that can help them to reach better decisions more rapidly. Because decision support systems can both improve the average quality of decisions and cut the costs of making them, they have a large potential for improving the efficiency and effectiveness of technical training systems. They offer the opportunities to accomplish more with fewer resources.

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Figure 11 summarizes how AFHRL is planning to provide management tools that could increase the efficiency and effectiveness of technical training in the Air Force.

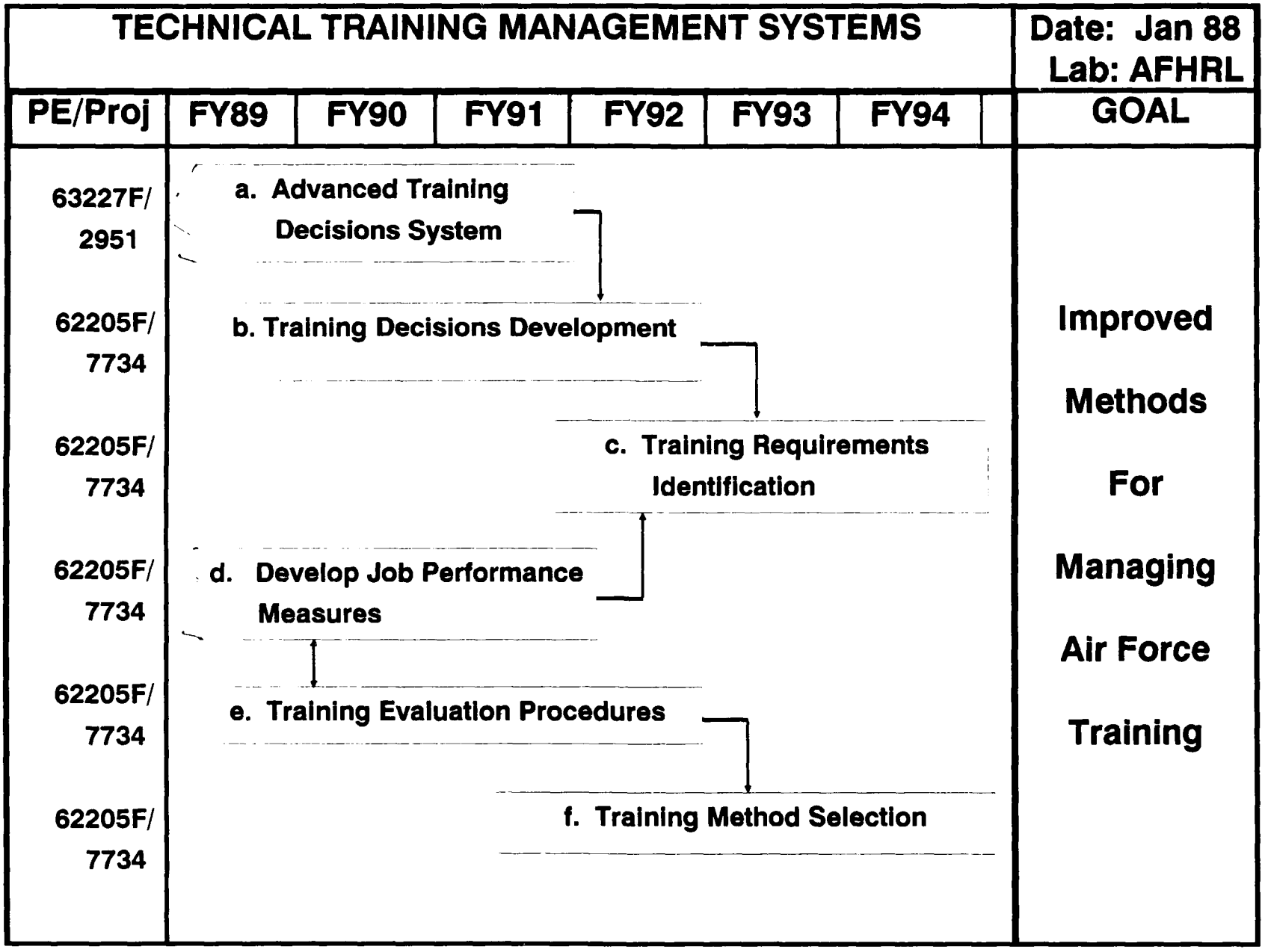

Fig 11. Training Technology Subthrust ID-2: Technical Training Management Systems.

a. Advanced Training Decisions System (TDS). Building on earlier exploratory development work, this effort will yield a prototype decision support system. The system will help the individuals charged with planning training for an Air Force specialty to better understand the implications of their decisions for costs and career development. It will deal with decisions about what tasks to train, where to train them, and when in enlisted careers to train them. TDS will be tested on four specialty areas. Full transition to an operating Air Force agency will be accomplished by FY92.

b. Training Decisions Development. This new project will build upon the same research base as TDS but will have a different focus. New missions, new tactics, and new technologies will impact continually what Air Force personnel will have to do. A capacity to forecast the impacts of such changes on Air Force jobs would help planners to anticipate such changes in their training planning rather than to react to them. The project aims to provide such planning tools by FY92.

c. Training Requirements Identification. The Instructional Systems Development (ISD) process provides a series of paper-and-pencil tools for the development of Air Force training courses. However, the ISD process is cumbersome and seldom used in its entirety. New programming techniques can be used to build upon the Training Decisions System and the Training Decisions Development work to provide a computerized job aid that would be both easier to use and more useful than the current ISD process. AFHRL aims to produce a prototype of such a job aid by FY94.

d. Develop Job Performance Measurement (JPM). Building on a prior exploratory development effort, this advanced development effort will provide a cost-effective procedure for measuring hands-on job performance. The measures will be used to validate the ASVAB and to develop and evaluate training programs. A performance measure technology for setting enlistment standards will be operational in FY91.

e. Training Evaluation Procedures. This effort will broaden the focus of the JPM effort. The JPM effort has been primarily focused on hands-on job procedures and skills. But, there are other facets of overall job performance. This effort will develop scientifically valid methods for measuring those aspects during FY89 - 92.

f. Training Method Selection. Once one can measure the important facets of job performance, one can start to address the effectiveness of different training media. This effort will do two things. First, it will estimate the effectiveness of different training methods for improving the important facets of job performance. Second, it will use quantitative conclusions about the effectiveness of training methods to build a decision support system for selecting training methods. The work will start in FY92 and be completed by FY94.

VI. PROGRAM RELATIONSHIPS

AFHRL is actively working to reduce unnecessary duplication of R&D efforts by participating in a tri-Service Commanders Meeting with the Army Research Institute (ARI) and the Navy Personnel Research and Development Center (NPRDC). Meetings are held quarterly, at which time programs are reviewed and joint initiatives are planned.

AFHRL also exchanges technology with allies through several programs. The Technical Cooperation Program (TTCP) provides for the exchange of information in the area of behavioral sciences with the United Kingdom, Canada, Australia, and New Zealand. AFHRL contributes to the North Atlantic Treaty Organization (NATO) by participating in the Psychological Fitness Study Group, Manned Communications Interaction in Command and

Control Panel, and the Aircrew Selection Working Group. AFHRL also has specific aircrew selection information exchange programs with the United Kingdom, Germany, and Australia.

With the anticipated decline of the service-eligible population in the 1990 timeframe, all the Armed Services are facing similar manpower and personnel problems in attracting sufficient numbers of eligible personnel into military service, enhancing productivity of the workforce, and retaining a quality career force. Based on the similarity of service issues and concerns, several tri-Service R&D working groups have been established to develop integrated and cooperative R&D programs to study these mutual problems. An example is the Joint Services Selection and Classification Working Group and its associated Technical Task Group. These two working groups plan a comprehensive program for the development and validation of enlisted operational and high school testing programs. Systematic technical coordination is attained through group planning sessions and the exchange of contract and in-house R&D proposals. A cooperative service project to plan, develop, and implement an adaptive testing program is currently being handled through membership on the Computerized Adaptive Testing Interservice Coordinating Committee (CATICC). An interservice R&D working group was established to focus on the development of on-the-job performance measures to be used in the validation of Service selection programs.

AFHRL maintains active technical coordination with the Air Force Wright Aeronautical Laboratories (AFWAL), Logistics Management Center (LMC), Aeronautical Systems Division (ASD), Armstrong Aerospace Medical Research Laboratory (AAMRL), Air Force Acquisition Logistics Center (AFALC), and Rome Air Development Center (RADC). The Integrated Design Support (IDS) system and Aircraft Battle Damage Repair are two major projects AFHRL is jointly working with AFWAL. Participants with AFHRL in the development of Reliability, Availability, and Maintainability in Computer-Aided Design (RAMCAD) include other Air Force agencies (AFWAL, RADC, and ASD System Program Offices [SPOs]). Other participants in RAMCAD R&D include the Naval Ocean Systems Center, Fort Belvoir R&D Center, and the Picatinny Arsenal through the Joint Logistics Commanders' RAMCAD working group. Coordination is maintained with the Integrated Electronic Warfare System (INEWS) SPO for a joint Maintenance and Logistics in Computer-Aided Design test under which an AFHRL scientist serves as assistant chief of the reliability and maintainability evaluation. AFHRL is working with the Navy Personnel Research and Development Center (NPRDC) and the Army Research Institute on tri-Service automated technical data evaluation. The human model in computer-aided design is a joint project between AFHRL and AAMRL. AFHRL personnel are members of the Joint Policy Coordinating Group for Logistics Research, Test, and Evaluation plus several joint-Service subgroups such as the RAMCAD panel. Close coordination is being maintained with agencies that will use the products developed by AFHRL R&D. A formal Memorandum of Agreement between AFALC and AFHRL has been signed to promote orderly transition of R&D products. As part of the agreement, an AFALC officer is collocated at the Logistics and Human Factors Division (AFHRL/LR) to assist in the transitioning process.

AFHRL cooperation with NAVAIR and the Naval Training Systems Center (NTSC) led to the development of a Universal Threat System for Simulators (UTSS) concept to address common Air Force/Navy problems in threat/EW subsystems development, acquisition, validation, and maintenance. The UTSS project will develop a standard data base of threat and electronic warfare models for real-time flight simulation applications.

Air Force Systems Command organizations with a direct supporting role in AFHRL's Aircrew Combat Mission Enhancement (ACME) program, a Forecast II project to enhance combat mission readiness through advances in flight simulation technology, include

AAMRL, AFWAL, and RADC. Participation from other DOD organizations includes the Army's ARI, and the Army Project Manager for Training Devices (PM-TRADE); the Navy's 66SC; as well as the Defense Advanced Research Projects Agency (DARPA) and the Defense Mapping Agency (DMA). A tri-Service effort in networking technology supports the ACME program. Its objective is to help accomplish interactive flight simulation and involves AFHRL, NTSC, PM-TRADE, and ARI. The DARPA protocol will be extended to meet the communication requirements of high-performance flight simulators. The payoff will be a standard communication network that all Services can use to accomplish multi-force combat simulation.

Team Training Systems research is also coordinated with many agencies. Close liaison is maintained with elements of the Tactical Air Command, including support of BLUE FLAG exercises and evaluations at the Air Ground Operations School. Systematic technical coordination is maintained with the Army and Navy through international programs such as The Technical Cooperation Program. Active interface is maintained with AAMRL's work on console design, man-machine interface, communication and decision making for tactical commanders. Work achieving a comprehensive training capability for tactical command and control teams is coordinated with RADC, Electronic Systems Division, 4441st Tactical Training Group (BLUE FLAG), Air Ground Operations School, Military Personnel Center, Air University, Ninth Air Force, Twelfth Air Force, HQ AFSC, Air Staff, and selected Army and Navy organizations. Research on human information processing is conducted jointly with RADC. AFHRL's program is unique in its emphasis on developing training and technology for Air Force tactical battlestaff members and commanders. Other programs make a contribution to this objective, but the AFHRL R&D is required in order to provide the Air Force with the full integrated technology that it needs.

Continuous technical exchange and coordination are also maintained in methodologies to support training system development, initial skills training, and on-the-job training (OJT). Effective liaison is maintained with pertinent industrial and educational programs. AFHRL is working with the Navy, Army, and several academic centers to coordinate the Air Force AI program. The Office of Naval Research (ONR) is working with AFHRL in the development of computer-assisted instruction by participating in the Intelligent Computer-Assisted Instructional (ICAI) Network. A project jointly sponsored by the Naval Training Systems Center (NTSC), ARI, and AFHRL will develop a student diagnostic model along with knowledge acquisition tools and authoring aids for applying the model to training domains. Another project is sponsored by ARI, ONR, and AFHRL to build intelligent coaches for the Ada and Prolog languages with the objective of developing principles and guidelines for developing other coaching systems. AFHRL is also working with RADC to develop a computer-based speech recognition system.

The Canadian and United States Governments are operating under a 50/50 cost-sharing agreement to develop a fiber-optic helmet-mounted display (FOHMD). The FOHMD offers an impressive advancement in display system technology with significant increases in brightness and resolution at a substantial savings in cost over conventional dome and dodecahedron displays. The Navy (NTSC) is working on a competing design and both will be ready for evaluation in the FY88 timeframe. AFHRL is also working with ARI and the DOD Training and Performance Data Center (TPDC) to develop expert systems for use by training systems designers.

R&D to develop a pilot performance measurement system is being accomplished by the Air Force, the Navy, the National Aeronautics and Space Administration, the University of Illinois, and the

Royal Air Force. In addition, the Army has several related research projects in the area of combat simulation, including work on a low-level sensor target identification system for attack helicopters.

Both the Army and the Navy have ongoing research in simulator effectiveness and are working jointly on the development of microprocessor-based part-task trainers with advanced interactive display capabilities. A tri-Service effort is also underway to develop standard data base formats for visual CIG systems (Project 2851, ASD/YWB). Continuous coordination is maintained with the Defense Mapping Agency on terrain presentation for low-level navigation and air-to-ground simulation.

Every year, AFHRL actively participates in the review and evaluation of the Independent Research and Development (IR&D) programs of industry. The scope of AFHRL's activities is illustrated by the actions that took place during FY86. AFHRL reviewed 69 company IR&D technical plans and found 382 projects relevant to the Laboratory. The largest number of relevant IR&D projects (195 projects with $91M proposed funding) was in the Logistics Technology area. Projects in this area were those concerned with logistics support analysis and forecasting; computer-aided design and manufacturing; life-cycle cost; reliability analysis; automatic test equipment; automated technical orders/data; and command, control, communications, and intelligence (C^3I).

During 1986, there was an increase in the application of artifi ial intelligence (AI) to maintenance diagnostics and C^3I. The second largest area reviewed in FY86 was Training Technology (183 projects with $88.6M proposed funding). Projects in this area include aircrew and technical training. Relevant projects were those concerned with flight simulator visual displays and image generation, simulation software, training technology applications, maintenance simulators, computer-based instruction, and Ada software development. There were also numerous IR&D projects concerned with the application of AI and knowledge-based expert systems to aircrew and technical training and pilot performance and workload studies. The Manpower and Force Management area had four relevant projects ($302K proposed funding) in personnel selection and occupational structure. AFHRL continues to actively solicit industry's interest in IR&D projects related to planned and ongoing Laboratory R&D programs.

VII. ACCOMPLISHMENTS

Some AFHRL accomplishments are summarized below by Technical Area.

Manpower and Force Management

1. Air Force Officer Qualifying Test (AFOQT) Development. Two new parallel versions of the AFOQT (P_1 and P_2) have been developed to replace the operational AFOQT, Form O. New forms of the AFOQT are developed periodically to refine the instrument and to limit possible test compromise. The AFOQT is composed of 16 subtests used to score five composites measuring cognitive abilities deemed relevant to officer success. It is the primary source of aptitude information used to qualify civilian applicants for officer precommissioning training through the Reserve Officer Training Corps (ROTC) and the Officer Training School (OTS). AFOQT results are also used, along with other criteria, in the classification of aircrew members as pilots or navigators. Several improvements in the officer testing program are realized with the implementation of AFOQT Form P. With the availability of two psychometrically equivalent forms, the scores of those who retest should provide a more accurate index of ability since practice effects from prior exposure to test questions can be controlled. Another improvement in the officer testing program is the use of a single answer sheet, with all scoring computerized and centralized at the Air Force Military Personnel Center.

2. Non-Line Officer Projection Model. A simulation model, user's guide, and documentation manual for projecting the non-line officer force have been developed. The non-line officer projection model simulates the personnel activity for each non-line competitive category (e.g., Medical Corps, Judge Advocate General's Office, Chaplain), produces displays of the personnel activities, and projects the non-line officer force structure for at least 10 years. A user-friendly routine allows the user to add, delete, and edit data easily and choose among report options. The model is written in SIMSCRIPT II.5 and runs on both mainframe and personal computers. The model will be used by Air Staff and non-line corps manpower and personnel decision makers and planners to evaluate the impact of policy decisions and promotion plans for each non-line officer category. The model has already been used to help establish the promotion rates for the August 1987 Colonels' Promotion Board.

3. Methodology for Generating Efficiency and Effectiveness Measures (MGEEM). A methodology for generating organizational effectiveness measures was developed as a multi-step procedure for commanders and managers. The MGEEM process is conducted by individuals skilled in group processes who guide managers and workers of target organizations in creating their own organizational productivity measurement systems. Computerized data on intended accomplishments are periodically reported to workers and managers according to the principles of feedback, goal setting, and incentives. These principles address issues such as the frequency and objectivity of feedback; the acceptability, difficulty, and feasibility of goals; and the connection between effort, performance, and reward. Field tests show that the MGEEM is acceptable to participants, produces a productivity measurement system judged by commanders/managers to be comprehensive, is cost-effective in that it relies largely on existing data, and is capable of improving an organization's productivity by 50 to 75 percent.

4. Logical Consistency Indices for ASVAB Test Items. The Air Force must be able to detect cheating and malingering by conscripts under conditions of national mobilization. The ASVAB consists of ten short tests, typically 20 to 30 items in length. Although each test measures a conceptually different content area, many of the items tap a number of similar aptitudes. This means that item scores can be compared for logical consistency; i.e., if an examinee knows or does not know the response to item A and B on one test, he should logically be expected to know or not know the response to items A and B on another test. Theoretical work involving mathematically advanced analysis was accomplished to establish which items on one short test should be looked at to determine whether cheating or malingering had taken place on another short test. Research with deliberate cheaters and malingerers showed that these latent-trait-based logical consistency checks were very good at identifying people who had been told to misrepresent their aptitudes by deliberately failing to answer some questions that they actually knew or by using advance information about correct responses. The results of this study will be implemented now to reduce cheating on the ASVAB, thus avoiding fraudulent enlistments by unqualified personnel. The information could also be used to detect malingering if a national mobilization were to occur.

Logistics Technology

1. Combat Maintenance Capability Methodology. This project was the first comprehensive effort to analyze the effect of predicted combat on maintenance while considering the simultaneous impacts of intense flying schedules, increased demands on maintenance, airbase attacks, aircraft attrition and battle damage, and other combat conditions. Three modeling techniques (TSAR, TSARINA, and DYNAMETRIC) were selected to provide optimal determination of logistics composites, theater airbase resources, and supply demands for wartime operations.

This effort provided methodologies to analyze the difference between peacetime and combat aircraft maintenance and the effects of this difference on sortie generation capability. The techniques can be used to better identify training requirements for combat tasks and to realistically assess the potential bottlenecks to sortie generation under combat conditions. The combined results of this effort provide, to HQ USAF, MAJCOM, Wing-level maintenance and logistics planners, policy makers and managers, methodologies to realistically assess the generation of wartime sorties, identify shortfalls and problem areas, and evaluate possible corrective measures using computer model simulation.

2. Mission Reliability Model (MIREM). MIREM is a program to evaluate the reliability and sustained operating capability of advanced fault-tolerant electronic circuits during early development. MIREM was developed by AFHRL/LR through a contracting effort. LR verified and tested the model with the help of RADC. MIREM works on integrated systems, achieving fault tolerance through dynamic fault detection, fault isolation, and reconfiguration. The model can also evaluate designs with "hard-wired" or "brute force" redundance. A feature of MIREM is its accurate reflection of reconfigurable, competing functions on system reliability. The user defines the resources necessary to support a required function (e.g., Identify Friend/Foe (IFF)), and the model will compute the probability of losing that function over a certain operating time. A critical failure occurs when there are insufficient working resources to support the function. As an analytic model, MIREM determines a specific value for Mean Time Between Critical Failures, Mission Completion Success Probability, and Failure Resiliency. The model also calculates the effects of undetected failures and false alarms upon system reliability by Mean Time Between Maintenance Actions, Mean Time to Repair, and Inherent Availability. These outputs provide four repair options: immediate repair, deferred repair, scheduled maintenance, and repair at degraded level. These options offer greater flexibility in evaluating and developing avionics design. In addition to a tradeoff and evaluating tool, MIREM can also be used as a predictor of performance during testing. MIREM will be used by AFSC/ASD, SPOs, AFWAL, ESD, and RADC to evaluate the reliability and operating capability of advanced fault-tolerant circuits.

3. Logistics and Human Factors/ Training Analysis of Future Gunship. Key decisions affecting the life-cycle cost of a weapon system program are made before full-scale engineering development begins. The Air Force lacked adequate methodology to analyze supportability issues during the conceptual design phase. At the request of the Aeronautical Systems Division (ASD), AFHRL developed and demonstrated techniques for analysis of the human factors, training, and logistics drivers for future gunship design and employment concepts. The ability to conduct quantitative analysis of supportability issues in the conceptual design phase will reduce weapon system life-cycle costs and increase supportability, improving overall warfighting capability.

This effort was a baseline supportability study of a representative, state-of-the-art technology, near-term replacement gunship. Emphasis was on quantification of selected resources for a specific weapon system design and developed missions and scenarios. The intent was to provide a baseline comparison system and accumulate preliminary data for a replacement gunship. A two-pronged approach was taken. A contractor-performed effort used analytical techniques to quantify selected logistics requirements. An in-house effort was also performed using computer simulation techniques to assess sortie-generation capability and maintenance manpower requirements. The application of these efforts to both the Replacement Gunship Program and Gunship III has been recognized by ASD. Findings from these studies have been incorporated in the Requests for Proposals (RFPs).

4. Digital Aircraft Damage Assessment and Repair (DADAR). DADAR is a tool to aid technicians in the assessment and repair of damaged aircraft. The key to DADAR's operation is a visual display of the aircraft which is linked to the computer data base. A damaged aircraft will likely have many missing or unrecognizable parts. The purpose of DADAR is to establish the pre-damaged aircraft configuration for comparison to the actual damaged section. Because one cubic foot of an aircraft requires more than one megabyte of computer storage, DADAR includes data on only one section of the aircraft. This small area contains many different systems and represents a very dense cross-section of the aircraft. Part numbers for any component can be obtained by positioning the cursor over the desired component and selecting that part. A complete parts list can be created by selecting all desired parts and sending them to the attached printer. The user has the option to increase or decrease the size of the picture to get more detail about a specific section or to see a general view of the entire area. The graphic can also be rotated to obtain views which are not possible with current paper data. A system such as DADAR allows inexperienced technicians to quickly determine the extent and criticality of aircraft damage. DADAR was evaluated at Warner obins ALC, Robins AFB, GA in FY87. User feedback was positive and identified areas for further research. Follow-on research will be conducted using a small flight line portable computer being developed by AFHRL/LR.

Training Technology

1. Training/Job Requirements System (TJRS). This R&D produced a validated methodology which uses operational maintenance data to define operator performance and training standards. TJRS also provides the mechanisms for dynamically linking maintenance data to the Air Force operational survey and specialty training standard processes, thereby enhancing their validity and reliability. Specifically, TJRS can: (a) generate reports describing all maintenance tasks performed by individuals over a specified time period; (b) form the basis of aircraft-specific job description reports for each maintenance AFS on work center level, base level, or Air Force wide; and (c) identify maintenance "trouble-spots" where more training is required. This system comprises the Management and Evaluation components of the Advanced On-the-job Training System (AOTS) R&D effort and will be implemented by major commands when AOTS is transitioned.

2. Maintainer's Associate. A portable job aid and training device was developed for troubleshooting portions of the F-111 6883 avionics test station. This system allowed exploration of several artificial intelligence-based diagnostic and training strategies, including software and user interface design. The design for the prototype incorporated human-machine interfaces to promote incremental skill acquisition and to decrease mental dependence on the Maintainer's Associate. Diagnostic skill development was promoted through user interfaces providing a variety of explanations about the reasoning behind the diagnostic process in a given troubleshooting situation. The Maintainer's Associate enables novice technicians to solve diagnostic problems beyond their own level of competence and teaches them how to solve future problems on their own. Although the Maintainer's Associate was not developed for operational use, it has provided the basis for developing intelligent tutoring systems by defining the concept, reducing the risks involved, and identifying the benefits that might occur.

3. Air Intercept Trainer (AIT). The AIT is a low-cost, high-fidelity, classroom device used for training F-16 air-to-air intercept skills. A dynamic simulation of F-16 head-up display and radar electro-optical display images is provided in near real time. Ownship maneuver capabilities are provided using F-16 throttle and stick controllers as input devices. The dynamic effects of

ownship maneuvers and target relative motion for single targets or for multiple targets, each with its own heading, altitude, and airspeed, are presented. The AIT incorporates an integrated instructor/operator station from which the instructor controls the intercept scenarios presented to the student. The trainer is currently being used in a transfer-of-training study with the Arizona Air National Guard. An AIT for the F-16C/D is currently being developed for Tactical Air Command. Follow-on development of an enhanced version of the F-16A AIT for the Air Force Reserve will include a visual and situational awareness display.

4. Air Combat Expert Simulation (ACES). ACES simulates decision making by expert fighter pilots in air-to-air combat. The actual program is on disk and runs on an IBM-PC with expanded memory. The ACES model is a desktop training system that engages the student in a series of mock combat situations, allowing the student pilots to learn about conditions that call for particular maneuvers. The ACES model predicts the selection of an air combat maneuver given the scenario of 1 vs 1 engagement. Selection rules are incorporated to determine which basic fighter maneuver to execute, given a description of an airspace with two competing T-38 aircraft. The aircraft are displayed in three-dimensional graphics. Maneuvers may be selected for either aircraft by either a user or ACES. In a transfer-of-training study with members of the Air National Guard, the selection maneuvers by ACES compare favorably with selections made by expert fighter pilots. Future development efforts include expanding from the T-38 to F-15 and F-16 domains, with plans for the Tactical Air Command to implement ACES at the operational squadron level.

5. Air Combat Maneuvering (ACM) Performance Measurement System (PMS). The ACM PMS is designed and developed to acquire real-time data from the simulator for air-to-air combat (SAAC) and the air combat maneuvering instrumentation (ACMI) range. The ACM PMS has the following capabilities: (1) real-time monitoring, recording, and scoring of ACM data from the SAAC and ACMI; (2) implementation of the all-aspect maneuvering index; (3) real-time graphic feedback; (4) hard-copy printout; (5) graphic replay for debriefing; and (6) data storage and analysis. The ACM PMS has been developed and integrated with the SAAC/ACMI. The ACM PMS will be used to conduct performance measurement and performance monitoring research. The computer link between the SAAC and the ACMI facilitates transfer-of-training research and research on which air combat tasks are best trained in the simulator or combat range.

6. First-Generation Decision Support System. This effort provided the first step to produce a decision support system (DSS) for Air Force part-task training devices and programs. The first version of the DSS is implemented on commercial data base management software. Future expansions will use specialized expert system software. The first-generation DSS asks the user to specify task components and component order. It uses this information, information about component interdependence and skill type, and the reasons a component is difficult to learn or perform, to make recommendations about partitioning and training. The results of this effort provided guidelines to partition complex flight tasks that are trained in actual equipment and simulators into parts that can be effectively trained on less expensive systems. The current part-task training DSS is a first attempt to determine what an enhanced DSS for part-task training could encompass.

7. Orbital Mechanics Tutor. This system was developed to provide an environment for discovering principles of ground traces as a direct function of the orbital elements. The system used artificial intelligence techniques to teach students how to "deduce" a satellite's orbital elements by looking at a graphic display of a satellite's ground trace. The system also teaches students how to use more systematic behaviors to explore

this domain. Since the system is equipped with a number of online tools that were specially designed to help students better understand facts, principles and relationships, the student is free to investigate different options and learn at his/her own pace. If, however, the student fails to make satisfactory progress, then the system intervenes and directs the student toward specific goals. The tutor will be transferred to the customer as soon as Space Command decides what kind of hardware they want it run on.

APPENDIX A: FORMAL REQUIREMENTS

RQMT NO	RQMT TITLE	USER(S)
AFR 30-23	The Air Force Personnel Survey Program	N/A
AFR 33-6	Armed Forces Vocational Testing Program	N/A
AFR 35-2	Occupational Analysis	N/A
AFR 35-8	Air Force Military Personnel Testing System	N/A
RPR 78-11	Selection for Pilot Training	ATC/XPRR, ATC/DOXP
RPR 78-12	Selection for Navigator Training	ATC/XPRR, ATC/DON
RPR-78-16	OJT and Task Training Decision Systems	USAF/DPPTS, ATC/TTXX, ATC/XPTT
RPR 80-01	Development, Test, and Evaluation of an Integrated Job-Oriented Literacy Assessment and Enhancement Program	USAF/DPPTS, ATC/XPRR
RPR 80-02	Selection for Flying Training Tracks	ATC/XPRR, ATC/DOXP
RPR 80-03	Prototype OJT Management and Delivery System	USAF/DPPT, AFMPC/DPMRPQ3
RPR 80-05	Beyond Visual Range Performance Measurement	TAC/DOTSR, 405TTS
RPR 81-09	Euro-NATO Joint Jet Pilot Training	USAF/DPPTF, USAF/XOOTD
RPR 82-08	Officer Data Base/Cohort File	USAF/DPAC
RPR 83-01	R&D in Support of ASVAB and CAT for ASVAB	USAF/MPXOA/DPPTS, AFLC/XRS/XRY
RPR 83-02	Improved Performance Measurement and Prediction	AFMPC/DPCRPQ, ATC/XPRR
RPR 83-03	Improved Techniques for Development and Use of Occupational Surveys	ATC/XPRR, USAFOMC/OMY
RPR 83-13	Aerial Refueling Part Task Trainer (ARPTT) Skills	MAC/DOT/XPQ

APPENDIX A: (Continued)

RQMT NO	RQMT TITLE	USER(S)
RPR 83-15	Simulator Radar and Visual Data Base Generation	SAC/XPHD
RPR 83-24	Improved Selection Procedures for Air Force Physicians	AFMPC/SGEP USAF/DPAC/DPXOP
RPR 84-02	Contingency Task Training Requirements	ATC/XPRR, USAFOMC/OMY
RPR 84-04	Validation of Job Difficulty Measures	ATC/XPTTT, USAFOMC/OMY
RPR 84-09	Model Aircrew Training System	MAC/DOT
RPR 85-01	Expansion of Person Job-Match Technology	AFMPC/DPCRPQ ATC/XPRR, AFRS/RSMC
RPR 85-02	Quantifying Experience in the Cost of Human Capital	AF/DPAC
RPR 86-03	PJM Methodology	AFMPC/DPMRAS4
RPR 86-04	R&D in Artificial Intelligence	ATC/XPRR, OMC/OMYO/OMT
RPR 86-05	Nonrated Officer Selection System	ATC/XPRR/RSCX, USAFRS/RSMM
RPR 86-20	Unit Level Mission Debriefing System	TAC/DOTSR
LDN 85003	Line Replaceable Unit (LRU) Functional Tester	AFLMC/LGM
LRN 85018	Digital Data Reader	AD/ALP
LRN 79014	Trade-Offs Among Training Manpower, Automatic Test Equipment, and Technical Data	AFALC
LRN 81022	Automated Decision Aid for Aircraft Battle Damage Assessment	AFCOLR, AFLC/XRXX, AFLC/XRS
LRN 81155	Biological/Chemical Warfare Effects on Aircraft Battle Damage Repair and Maintenance	AFLC/XRXX, AFALC/PTN
LRN 82027	Factors for Wartime Requirements Assessments	AFLC/XRSL, AFALC/PTN
LRN 82116	Integrated Computer Aided Sustaining Engineering	AFLC/XRI

APPENDIX A: (Concluded)

RQMT NO	RQMT TITLE	USER(S)
LRN 84046	Expansion of Unified Data Base (UDB) Capability	AFALC/PTN
LRN 84054	Maintenance Air Force Specialty Code (AFSC) Compression	AFLC/XRX
LRN 84081	Maintenance and Logistics Factors in Computer-Aided Design	AFHRL/LRA
LRN 86021	Interactive Video Enhancement	AFCC/LGMMT
LRN 87031	Fully Automated Aircraft Maintenance Data Collection	SAC/LGME
TN-ASD-0509-82-63	Flight Simulator Performance Metrics	ASD/EN
TN-ASD-0508-82-65	Image Generation for Flight Simulator Visual System	ASD/EN
TN-ASD-0508-82-66	Visual System Display	ASD/EN

APPENDIX B: FUNDING ($M)

PROGRAM ELEMENT	TITLE	ACTUAL FY87	EST FY88	EST FY89	EST FY90
61101F	Lab Dir Indep Rsch Prog	0.8	0.9	0.9	0.9
61102F	Defense Rsch Sci	1.0	1.0	1.0	1.1
62205F	Tng and Sim Tech	23.1	30.0	31.0	30.7
62703F	Pers Util Tech	8.0	0	0	0
63106F	Log Sys Tech	11.4	8.9	12.4	10.6
63227F	Adv Sim Tech	4.0	7.5	8.0	8.8
63704F	MP and Pers Sys Tech	1.4	0	0	0
63751F	Tng Sys Tech	1.8	0.3	0.5	0
63248F	Concept Dev	5.4	0	0	0
TOTAL		56.9	48.6	53.8	52.1

FUNDS RECEIVED FROM OTHER SOURCES (FY87)

As of 30 Sep 87 a total of $8.0M was received from other sources to support R&D programs of mutual interest.

LABORATORY OPERATIONS	FY87	FY88	FY89	FY90
6.1	.5	.5	.5	.5
6.2	10.1	11.1	11.2	11.4
6.3	1.4	1.7	2.0	2.1
TOTAL	12.0	13.3	13.7	14.0

APPENDIX C: MANPOWER

NUMBER AUTHORIZED FOR FY87:

OFFICERS 102 ENLISTED 89 CIVILIAN 214 TOTAL 405

PROFESSIONAL CATEGORY:	OFFICERS	ENLISTED	CIVILIAN	TOTAL
Scientific and Engineering (S&E)	96	1	112	209
Technical	4	65	39	108
Other	2	23	63	88
TOTAL	102	89	214	405

ACADEMIC DEGREES:	BACHELORS	MASTERS	PHDS	TOTAL
Psych/Human Factors	18	35	36	89
Computer Sci/Info Sci/Math	26	11	5	42
Engineering	31	4	0	35
Business Adm/Management Sci	16	17	3	36
Education	5	2	4	11
Other	11	10	1	22
TOTAL	107	79	49	235

APPENDIX D: FACILITIES

The primary facility at Brooks AFB TX, Bldg 578, houses the Laboratory Headquarters, the Manpower and Personnel Division, the Information Sciences Division, the Training Systems Division, and a Sperry 1100/81 computer. Three staff offices--the Technical Programs and Resources Office, the Special Projects Office, and the Executive Support Office are also located in Bldg 578. The building contains 73,640 sq ft. A second building at Brooks is Bldg 1155 with 1620 sq ft which houses AFHRL archival material. An annex to Bldg 578, scheduled to be completed 1 January 1989, will contain 3200 sq ft and be occupied jointly by the Manpower and Personnel Division and the Training Systems Division. The Manpower and Personnel Division also has a Testing Branch, which is contained in Bldg 9016, and two other buildings at Lackland AFB TX totaling 14,452 sq ft. The Advanced On-the-job Training System (AOTS) Project, part of the Training Systems Division, is located at Bergstrom AFB TX, in two buildings containing 4,810 sq ft. The Logistics and Human Factors Division at Wright-Patterson AFB OH is housed in two buildings containing 33,150 sq ft. The Operations Training Division at Williams AFB AZ is located in eight buildings occupying 59,969 sq ft. Building 558 with 22,485 sq ft also houses the Advanced Simulator for Pilot Training; Bldg 560 with 9,600 sq ft was accepted in November 1980. The Operations Training Division also occupies two buildings at Luke AFB AZ with a total of 3060 sq ft. Altogether the AFHRL facilities include 19 buildings for a total of 187,701 sq ft as of January 1988.

AFHRL FACILITIES

	SQUARE FOOTAGE	FACILITY ($K)[a]	S&E EQUIP ($K)
Brooks AFB TX--2 Bldgs	75,260	2,483	4,681
Bldg 578: o Laboratory HQ o Manpower & Personnel Division o Information Sciences Division o Training Systems Division o Technical Programs and Resources Office o Special Projects Office o Executive Support Office	73,640		
Bldg 1155--Archives	1,620		
Lackland AFB TX--3 Bldgs	14,452	440	1,013
Bldg 9016-Testing Facility	5,012		
Bldg 6320-Terak Computer Testing	4,720		
Bldg 6321-Paper and Pencil Testing	4,720		
Bergstrom AFB TX--2 Bldgs AOTS Project	4,810	222	50
Bldg 428-Contract Personnel	1,600		
Bldg 1808-AFHRL ID Personnel	3,210		

Wright-Patterson AFB OH--2 Bldgs Logistics & Human Factors Division	33,150	548	1,981
Bldg 190-AFHRL LR Personnel	21,600		
Bldg 434-Contract Personnel	11,550		
Williams AFB AZ--8 Bldgs Operations Training Division	56,969	7,028	103,616
Bldg 551-Administration & Computers	2,200		
Bldg 554-Administration & Computers	2,200		
Bldg 558-ASPT Cockpits	22,485		
Bldg 559-Contractor Personnel	704		
Bldg 560-PDT Lab, UNIVAC 1108	9,600		
Bldg 562-Engineering Support	4,200		
Bldg 567-Administration & Computers	2,200		
Bldg 570-Simulator/Research Facility	13,380		
Luke AFB AZ--2 Bldgs Air-to-Air Combat R&D	3,060	N/A	N/A
Bldg 616-Contract Personnel	2,760		
Bldg 617-Contract Personnel	300		

[a] Cost of acquisition.

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